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BRITISH FOUNDRYMEN'S ASSOCIATION.

Specifications for Foundry Pig-Irons.

By W. B. PARKER, F.I.C.

THE advantages which will undoubtedly follow the general adoption of a system of specifications for pig-irons are so obvious to everyone familiar with foundry requirements that we need not deal with that side of the question, so the author will confine his remarks to the query whether such a system can be evolved without unduly disturbing present systems of supply.

When compiling specifications for foundry pig-irons we must consider:—

Firstly. The compositions and grading of the chief classes of pig-irons already in use.

Secondly. The compositions and grading which will be most suitable for the largest number of purposes, or for the largest individual demands.

Keeping these points in sight, the author believes it is quite possible to compile specifications for the pig-irons used in British foundries which will prove practicable from both the maker's and user's point of view. The author will particularly direct your attention to the first item, which is a very important one, because the limits embodied in the specifications must be based upon it. After reviewing the present methods of grading, etc., the author will endeavour to show how specifications which are now actually in use have been formulated.

The Composition of the Chief Classes of Pig-Iron.

It has already been pointed out by several authorities that the composition of a pig-iron varies with the district in which it is produced, because of the local characteristics of the ores smelted. Some recent writers have stated this is no longer a positive fact, owing to the exhaustion of local ores. The author's own experience indicates there are still decided local characteristics, but that the characteristics and boundaries of the localities do not coincide exactly with

those which formerly held good. Upon examining a number of recent analyses of pig-irons, it will be found that the irons are divisible into about four main groups, and that the most important of these groups coincide with, or are characteristic of, the chief pig-iron producing districts. Obviously, any natural classification which does exist should be utilised as far as possible. There always remain a few kinds of pig-irons which can only be dealt with by placing them in a miscellaneous or special group. If this method is adopted it is possible to divide the well-known pig-irons into four groups, namely :—

Group I., Special Pig-irons.
Group II., English Pig-irons.
Group III., Scotch Pig-irons.
Group IV., Hematite Pig-irons.

Group 1.—Special Pig-Irons.

In the first group are included those pig-irons which are generally high in price and used in limited quantities for special purposes, as, for example, those commonly known as :—

(*a*) South Staffordshire "all-mine" pig.
(*b*) Cold blast (both English and Welsh).
(*c*) Swedish charcoal iron (both hot and cold blast).
(*d*) Also the quality called "refined pig."

This group presents the greatest difficulty in classification according to analyses, but the author hopes to show later it is possible to arrange it in an orderly manner.

Group 2.—English Pig-Irons.

In the second group are included the ordinary English pig-irons, as, for example, those which are commonly known under the trade names of :—

(*a*) North Staffordshire.
(*b*) Derbyshire.
(*c*) Lincolnshire or Frodingham.
(*d*) Northamptonshire.
(*e*) Cleveland or Middlesbrough.

The most characteristic feature of the pig-irons of this group is that they all contain a high percentage of phosphorus —it is rarely below 1 per cent., and is usually nearer 1.5 per cent. It is further noticeable that the sulphur in the first three "grades" or foundry "numbers" is almost invariably below .06 per cent., and even in the fourth grade rarely exceeds .08 per cent. For purposes of specification it is necessary to sub-divide this group into two classes, which the author will call Class X, containing a low percentage of manganese, and Class Y, containing a high percentage of manganese.

In Class X, (Group 2) is included Northamptonshire and Cleveland pig-iron. In these we rarely find the manganese exceeds .75 per cent., and judging from the author's own experience, it is most usually under .6 per cent.

In Class Y (Group 2) is included North Staffordshire, Derbyshire, and Lincolnshire, (*i.e.*, Frodingham) pig-irons. In these irons the manganese rarely falls below .75 per cent., and usually runs 1 per cent., or just over.

Now the above difference is a natural one, for it is based upon differences in the ores smelted, and it must be taken into account when making specifications for English foundry irons.

Group 3.—Scotch Pig-Irons.

In the third group is included the ordinary Scotch pig-irons, which are commonly sold in this district. As fair representatives of them may be mentioned the brands :—Glengarnock, Carron, Gartsherrie, and Summerlee. The above are, of course, only a few brands taken from many. There does not appear to be any cause for a subdivision of this group, the irons of which are all characterised by a combination of high manganese and moderately high phosphorus. That is, the manganese is seldom as low as .6 per cent., and is usually .9 per cent., or just over. The phosphorus may reach just over 1.0 per cent., and falls as low as .5 per cent., but we do not see many samples as low as .5 per cent. Here again we find the first four grades or foundry numbers seldom contain over .06 per cent. of sulphur.

Group 4.—Hematite Pig-Irons.

Group 4 is a very comprehensive one, for it can include *all* makes of hematite, whether English, Welsh, or Scotch. By hematite iron is meant iron made from pure, low phosphorus ores, using hot-blast and coke or coal fuel. This definition distinguishes it from irons of a nearly similar chemical composition such as Swedish iron, which are put in Group 1. Perhaps it ought to be pointed out that to the users of the iron it is really a matter of no importance from what ores hematite iron is produced, provided its composition comes within specification, and its price is that usually quoted for such pure iron. The characteristic of Group 4 is the very low percentage of sulphur and phosphorus. The

grade members usually required for ordinary foundry use are Nos. 1 to 3, and occasionally No. 4. A genuine and properly made hematite of these grades should **not** contain over .06 per cent. of either sulphur or phosphorus, and the percentages are usually below .05 per cent. There are, however, two distinct types of hematite—one which contains a high percentage of manganese (that is, *over* .75 per cent.), while the other contains a low percentage (that is, NOT *over* .5 per cent. This makes it necessary to subdivide this group into two classes for specification, and in this instance we find this distinction actually in use in the trade under the terms of :—East Coast hematite and West Coast hematite, which are high and low in manganese respectively.

We will now revert to Group I.

All-Mine Pig-Iron.

The author's experience with "all-mine" pig-iron is not extensive, but so far as it goes it indicates this quality of iron usually contains between .2 and .7 per cent. of phosphorus, between .06 and .2 per cent. of sulphur, and the manganese is under .75 per cent.—these are very wide limits for a special iron. The standard for this material is difficult to settle, because the temperature of the blast used may be varied considerably, also the proportion of one ore to the other, and there seems no definite standard of composition generally adopted by the makers. The only fixed point in the production of this iron is that no "cinder" or "waste-product" of that kind is used for manufacturing the *genuine* article. The percentage of phosphorus is controlled by the quality of the ores charged, and the percentage of sulphur mainly by the temperature of the blast, and the furnace burden, *i.e.*, the ratio of ore to fuel.

Therefore, the *maximum* limits of composition for "all-mine" pig-iron made with hot, or coddled blast, may be taken as :—

Phosphorus not over .7 per cent.
Sulphur not over .1 per cent.
Manganese not over .75 per cent.

Logically speaking, when a *cold*-blast is utilised for the manufacture of an "all-mine" iron, the product should be termed a "cold-blast" iron, and not an "all-mine" iron, because it is generally understood that the iron sold as "cold-blast" is also an "all-mine" product—that is, there is no cinder in the charge smelted. If this nomenclature is adopted, the term "all-mine" should be reserved for the product of furnaces worked with a hot, or semi-hot, blast, and smelting nothing but ore. This is, of course, no attempt to dictate to manufacturers as to methods of working, but it is a hint to them that their product should be *sold* under a name which leaves no doubt in the mind of the purchaser as to the class of metal being offered to him.

Sometimes we notice pig-irons sold under the terms "refined," or "special refined," or simply "special." These usually contain less impurity than the "all-mine," but do not equal genuine "cold-blast" in strength, nor in price. Probably, they are semi-hot blast "all-mine" pig-irons. If so, it would not harm their producers to definitely label them as such.

Cold-Blast Iron.

Genuine "cold-blast" irons of British manufacture usually contain *under* .4 per cent. phosphorus and *under* .06 per cent. sulphur. In the strongest brands the phosphorus is generally *below* .2 per cent. The highest manganese I have met with in cold-blast iron is .6 per cent. The maximum limits for cold-blast iron may, therefore, be placed at :—

Phosphorus not over .4 per cent.
Sulphur not over .06 per cent.
Manganese not over .60 per cent.

It is not uncommon for makers to report very much higher manganese than their iron really contains. It may be that the makers' results are not up to date, or are the average of a very long period, but I would particularly warn you from trusting reports of analyses marked "Approximate"—they are useless.

Swedish Iron.

The charcoal irons of Sweden are exceptions to ordinary limits, because only pure ores and the purest charcoal are used for their production.

The blast may be either hot or cold, but in both cases the iron is of exceptional purity.

The following table shows the partial analyses of ten different brands of Swedish pig-iron. The first two are cold-blast irons, the others are hot-blast irons. The phosphorus and sulphur are almost invariably well below .05 per cent., and in all cases the manganese is low. The Swedish "Bessemer" steel-makers consume practically all their pig-iron which

is high in manganese, hence it is rarely offered to British foundries.

Table No. 1.—Partial Analysis of Swedish Pig-Irons.

Brand.	Silicon.	Sulphur.	Phosphorus.	Manganese.
	Per cent.	Per cent.	Per cent.	Per cent.
ÅB ÅB	2.40	.05	.03	.32
ÅÅ	1.10	.03	.03	.17
Bredjso	.55	.01	.02	.09
SBH	.33	.01	.02	.40
WS	.20	.02	.02	.10
WÅS	1.10	.02	.04	.10
Herrang	.44	.02	.01	.04
H	.15	.01	.03	08
FF	2.92	.02	trace	not estimated
LBoNLL	2.86	.01	.01	.25

Cylinder Mixtures.

Finally, there is one other quality of iron which is used in several districts for "cylinder mixtures." The author has only met one representative of it, namely "Goldendale."

This iron has a composition intermediate between a "basic iron" used for steel-making, and the English foundry irons of Group 2, Class Y. As you probably know, basic iron is a white iron, very rich in both phosphorus and manganese, containing usually over 2 per cent. of each. Now "Goldendale" is also very high in phosphorus, generally containing between 1.3 per cent. and 2 per cent. It is also high in manganese—the author has known it to contain over 1.5 per cent., but occasionally it falls as low as .75 per cent.

I have seen analyses of Goldendale reporting as high as 3 per cent. of manganese. The sulphur varies from .06 to .10 per cent. It is probable that it is the combination of high manganese and high phosphorus which gives this iron the fracture here shown. It is an iron which requires considerable care in using, but its high manganese often proves very useful.

The author is inclined to place it in Group II. Class Y, but the grading is different, and its lower numbers usually command a much higher price; therefore, he has decided to put it in Group I. We have now dealt with the elements which keep fairly constant in all the "grades" or "numbers" for each particular group or class. To complete the specifications we must fill in the silicon and carbon.

"Grading."

You are all familiar with the present antiquated system of "grading by fracture." If we sift this system down to its real basis we find it is founded upon two chief properties.

Firstly. The relative hardness of the iron as indicated by the *amount* of graphite visible.

Secondly. The relative *size* of the graphite plates which are visible upon a freshly fractured surface.

Taking the first item :—

"Relative Hardness."

We know from researches by Professor Howe, Professor Turner, and others, the hardness of pig-iron or cast-iron is almost directly proportional to the percentage of combined carbon it contains.*

In "grading by fracture" it is assumed that the more graphite visible, the lower is the percentage of combined carbon—but this is not by any means constantly true. The author has often noticed fractures show every appearance of the iron being high in graphitic carbon, and therefore *low* in combined carbon, but upon analysis they proved to be much higher in combined carbon than properly corresponded to the grade they were sold as. The quantity of graphite *visible* is merely a very rough and often inaccurate indication of the percentage of combined carbon, and consequently of the hardness of pig-iron. It is not accurate enough for modern requirements. The elements other than carbon I will term impurities. Some of the impurities also have a hardening effect "*per se*," *i.e.*, when they are present in maximum percentages, but compared with the effect of combined carbon their *direct* hardening is small, and for ordinary grading purposes may be ignored. We cannot, however, ignore their *indirect* effect upon the hardness—

* See Howe's "Iron, Steel, and other Alloys," p. 438.

this has an important bearing upon the question of grading. We can classify the impurities into two divisions according to their *indirect* effect upon the hardness thus :—

(1.) Softeners : Silicon.

(2.) Hardeners : Sulphur, manganese, and, possibly, phosphorus. They act through the medium of the carbon. Taking equal percentages, the softening effect of silicon is much greater than the hardening effect of the other elements. Consequently, both the percentage of combined carbon, the hardness, and, to a certain extent, the quantity of visible graphite, are controlled mainly by the percentage of silicon.

Size of Graphite.

The *size* of the graphite plates is chiefly influenced by the relative rate of cooling. The "rate of cooling" depends upon : the initial temperature of pouring; the mass of metal cooled—that is, the size of the pig; also upon the percentage and nature of the impurities. As far as foundry practice is concerned the *size* of the graphite plates in pig-iron is unimportant, and would be kept fairly constant by working within the limits of impurities set down for each group of iron.

The logical deduction from these facts is that the best method of *grading pig-irons* of all qualities is by means of the percentages of *both combined carbon and silicon*. This raises the question: "Are the percentages of combined carbon and silicon per grade *identical* in *all* groups and classes?"—I find they are *not* so!

Broadly speaking, in the groups and classes containing *high* manganese, the percentage of silicon per grade is lower than in those containing low manganese. Consequently, in the groups and classes containing *high* manganese the percentage of combined carbon per grade is higher than in the groups containing low manganese. That is, the percentage of combined carbon per grade will differ slightly for each group and class, but should be a constant quantity in any individual group or class of iron.

We can hardly expect corresponding grades of two different groups—as, for instance, Scotch (Group 3) and English (Group 2, Class X)—to have exactly the same percentage of combined carbon, or silicon.

Although much research has been conducted with the purpose of deciding the important question of "What is the exact percentage of silicon required to control the percentage of combined carbon in pig-iron?" this question is not yet definitely settled, but we do know the percentage with sufficient accuracy to grade the iron for commercial purposes by its means. In commercial work, however, there must always be a slight overlapping of the limits of silicon for neighbouring grades. The amount of overlapping will, in my opinion, be about two-tenths of a per cent. either side, and it is for this reason the author strongly advocates definitely fixing the maximum percentage of combined carbon for each grade, and allowing a working margin upon the percentage of silicon corresponding to it. For, after all, it is really the combined carbon which determines the grade of the iron, and not the silicon. The silicon is merely an aid to controlling the grade, and also of keeping the grade practically unaltered during remelting in the cupola.

Professor Turner, in his lectures upon foundry work, emphasises the importance of the combined carbon in the following words :—

"Though a moderate alteration in the proportion of total carbon, or graphite . . . . will frequently have but little effect on the physical properties of the product, a *small* change in the proportion of combined carbon will often very materially alter the strength . . . . and its suitability for the purpose in view.

"Probably no other constituent . . . . is so important in its effect as combined carbon, and, in fact, the influence of the other elements is largely due to the effect which they are able to produce by increasing or diminishing the proportion of carbon which is retained in the combined form." I fully endorse these remarks, and will add that any system of grading pig-iron which does not clearly define the maximum combined carbon for each grade will prove of limited value, because, practically and scientifically, this constituent is the true basis of grading. This brings up the question as to within what limits the composition of pig-iron can be controlled.

Blast Furnace Practice.

Data upon this point is meagre—one of the best papers upon the subject is that by F. Wurst, which you will find in "Stahl und Eisen," Vol. XXV., but it refers to German practice. Professor Turner gives a good example on page 198 of his "Metallurgy of Iron," which illustrates the variations found in silicon—this also is from German practice. The

following table (No. 2), illustrates this point:—

TABLE NO. 2.—"*Variations in Percentage of Silicon in same Tapping of Blast Furnace.*"

No. of Test.	Bottom 1	2	3	4	5	6	Top 7	Maximum Difference
1	1.13	1.15	1.15	1.19	1.33	1.40	1.42	.29
2	1.38	1.44	1.45	1.60	1 63	1.72	1.79	.41
3	1.15	1.34	1.43	1.57	2.17	2.18	2.20	1.05
4	1.49	1.50	1.54	1.66	1.82	1.84	1.88	.39
5	1.95	2.09	2.13	2.45	2 70	2.72	2.76	.81
6	1.81	1.83	1.84	1.86	1.89	2.16	2.20	.39
7	2.72	2.74	2.77	2 79	2 85	2.88	2.88	.17
8	2.46	2.48	2.50	2.53	2.54	2.58	2.60	.14

Eight Tappings, seven samples taken from each, and numbered so that number one represents the first metal (from bottom of hearth) and number seven the last metal (from top of hearth). (Taken from "Turner's Metallurgy of Iron," page 198).

"The word 'bottom' refers to the metal which lay on the bottom of the blast furnace hearth, and therefore ran out of the tap hole first when tapped. The word 'top' refers to the metal which lay against the slag and coke, near the tuyeres, and therefore came out last of all when tapped. The horizontal numbers are the sample numbers taken during each tap." Probably when the managing staff in charge of blast furnace plant has had a good metallurgical training, and applies that training scientifically to the work, the various impurities can be controlled within the following limits:—

Silicon within .25 per cent. either side any specified percentage.

Manganese within .25 per cent. either side any specified percentage.

Sulphur within .01 per cent. either side any specified percentage.

Phosphorus within .02 per cent. either side any specified percentage.

There is one other item to be mentioned, namely, the total carbon. Except for special work this is not of sufficient importance to warrant being rigidly specified, because unless it is below 2.75 per cent. or over 4.0 per cent. it has little influence upon the use of the pig-iron.

The Elements Specified.

In specifications for foundry pig-irons we need to specify:—

1*st*. The combined carbon and silicon to fix the grades.

2*nd*. The impurities, phosphorus, sulphur, and manganese to fix the quality.

The first of these items is sufficient reason for prohibiting the use of "machine-cast" pig, and the second is a splendid reason for the introduction of a "mixer," or "fore-hearth," or a large "ladle" into which the metal can either flow continuously (as in the so-called "continuous-flow" process) or be tapped periodically before it is poured into pig-iron. Every blast furnace plant should include a chemical laboratory, sufficiently equipped to enable it to deal with orders specifying "grades" and "quality" by analysis—at present only a few appear to possess this facility.

That a laboratory would soon pay for itself is shown by instances like the following, which constitute most telling condemnations of the present system of grading by fracture. (See Table 3.)

TABLE NO. 3.—*Incorrect* "*Grading by Fracture.*"

Item.	No. 1 Grade.	No. 2 Grade.	No. 3 Grade.	No. 4 Grade.
Graphitic Carbon	3.49	3.25	3.50	3.26
Combined "	.08	.08	.08	.08
Silicon	3.00	3.00	2.90	2.95
Sulphur	Trace	Trace	Trace	Trace
Phosphorus	1.49	1.43	1.39	1.60
Manganese	.29	.29	.22	.22
Price per ton	48s. 6d.	46s. 6d.	44s. 6d.	43s.
Description of the Fractures (given by makers).	Extra soft, very open grain	Open grain. Soft and Grey	Soft, Grey.	Close grain, Grey.

Irregular Grading.

The analyses, prices, and descriptions

of fractures given below were sent by a manufacturer in reply to an order for pig-iron of a given analysis.

The irons are truly all *just on the verge* of No. 1 grade, but the author would have labelled them all No. 2's, worth 46s. 6d. per ton. The prices prove that by sticking to the ancient method of grading, the manufacturer will be losing between 2s. to 3s. 6d. per ton upon every ton he sells of the iron he has graded as No. 3 and 4, or, say, £25 to £50 per week, while, on the other hand, a buyer of the iron called No. 1 would be paying 2s. per ton more for it than it was worth. This is by no means an isolated example of what I term "abnormal" grading.

The next three tables (Nos. 4, 5, and 6, will show that other users also experience this trouble.

These tables are from a paper read by Mr. P. Munnock before the Cleveland (Eng.) Institute of Engineers.

The first gives his idea of "standards" for Cleveland or Middlesbrough foundry pig.*

The next shows the composition of what has, at various times, been delivered for Cleveland pig.

Notice the ridiculous variations in *combined carbon* (Column No. 1) and *silicon* (Column No. 4) in the case of No. 3 grade (Table 5).

There is no excuse for such variations, they either indicate careless grading or inherent faults in the system of "grading by fracture"—the author thinks it is the latter.

The same applies to Table No. 6, showing the composition of various deliveries of hematite iron.

Mr. Munnock has apparently only given *East* Coast hematite in Table No. 6. But it shows how very abnormal the grading of Nos. 1, 2 and 3 hematite often happens to be when performed according to the present system.

TABLE No. 4.—"*Cleveland Iron—Ideal Analysis.*" (BY MR. P. MUNNOCK.)

Grade.	Combined carbon per cent.	Graphitic carbon per cent.	Manganese per cent.	Silicon per cent.	Sulphur per cent.	Phosphorus per cent.
No. 1	.10	3.30	.65	3.50	.02	1.60
No 2	.15	3.20	.65	3.30	.03	1.57
No. 3	.30	3.00	.60	2.75	.05	1.57
No. 4 Foundry ...	.40	2.85	.55	2.25	.08	1.55
No. 4 Forge	.70	2.50	.50	1.75	.13	1.57
Mottled	1.30	1.77	.30	1.10	.25	1.58
White	3.05	nil	.20	.75	.45	1.60

TABLE No. 5.—"*Cleveland Irons—Actual Analysis.*"

Grade.	C.C. per cent.	G.C. per cent.	Mn. per cent.	Si. per cent.	S. per cent.	P. per cent.
No. 1	.15	3.15	.60	2.50	.033	1.59
No. 3	nil	3.10	.55	3.65	.040	1.39
No. 3	.80	2.60	.57	1.40	.054	1.54
No. 4 Foundry ...	Trace.	2.95	.61	3.53	.033	1.51
*No. 4 ,, ...	.56	2.69	.40	2.10	.081	1.60
*No. 4 ,, ...	.97	2.47	.39	1.21	.075	1.53
†No. 4 ,, ...	From.			2.24		
†No. 4 ,, ...	To.			3.96		
No. 4 forge	.50	2.65	.40	2.45	.095	1.61
No. 4 ,, ...	1.12	2.17	.27	.93	.141	1.56
Mottled	1.46	1.76	.32	1.75	.280	1.59
,, ...	.90	2.30	.31	.93	.237	1.63

* In one and the same delivery.
† In one and the same delivery.

Standardisation of Purity or Quality.

There appears no good reason why all

* See "Foundry Trade Journal," p. 27, September, 1905.

pig-iron manufacturers, situated within geologically similar localities, and who must be using very similar grades of ores, should not agree to work to a fixed standard of "purity" or "quality." That is, they could agree to arrange their charges so that the percentages of phosphorus, sulphur, and manganese should be within certain percentages. The margin for these items should, of course, be made as wide as possible, consistent with the "quality" generally expected from each particular locality, and with the possibilities of modern blast furnace practice. For example, the author believes nearly all manufacturers within, say, Northamptonshire, could work to the following specification for these three items :—

Standards of Purity for English Irons Group II. Class X.

P Not over 1.5 per cent.
Mn " " .75 "
S (grades 1 to 3) not over .06 per cent.
S (grade 4) " " .08 "

Standards of Purity for Group III (Scotch).

P Not over 1.0 per cent.
Nor under .5 "
Mn Not under .9 "
Nor over 2.0 per cent.
S (grades 1 to 3) not over .06 per cent.
" (4 & 5) " .03 "

Standards of Purity for Group IV. (East and West) Hematite.

East.	Per cent.	West.	Per cent.
P Not over ...	... .06	P Not over...	... .06
S " " ...	... .05	S " " ...	... .05
Mn Not under	... .60	Mn " " ...	... .50

TABLE No. 6.—*Hematite Irons (East Coast) Actual Analysis.*

Grade.	C. C. per cent.	G. C.	Mn per cent.	Si per cent.	S per cent.	P per cent.
No. 1			1.35	5.25		
"			.93	2.39	.027	.06
"	.96	3.77	.72	1.04	.027	.08
No. 2				1.75	.038	.06
"	.92	3.14	1.38	1.23	.043	.04
No. 3	.55	3.15	.75	1.40	.080	.06
"	.45	3.33	.90	3.10	.030	.06
No. 4 Forge	.40	3.02	1.12	2.91	.095	.042
" "	.73	3.13	.48	.60	.116	.065

and so on for the "special" irons, which the author cannot deal with in this paper.

Such a "standardisation of purity" could not "hamper" the trade, for it is well known that in any particular locality the prices of the various brands produced in it do not differ considerably one from another, nor does their purity, the two being practicably inseparable. Any differences in prices which happens to exist is mainly due to "demand," that is, some brands are better known that others, and probably by limiting their "output" some makers obtain a slightly enhanced price owing to foundrymen having a preference for dealing with them. Such preference seldom has any true scientific basis—it practically amounts to a personal prejudice against others brands. The "cost of carriage" also accounts for some differences in quotations, because iron producers situated nearest to their customers can obtain higher prices by taking advantage of the handicap which

TABLE No. 7.—*"Grading by Analysis, allowing for 'Over-lapping.'" English Irons, Group II., Class X (Low Manganese).* By W. B. PARKER.

Item.	Limit.	No. 1 Grade	No. 2 Grade	No. 3 Grade	No. 4 Grade
		Per cent.	Per cent.	Per cent.	Per cent.
Silicon	Maximum	4.0	3 5	3.25	3.0
	Standard	3.5	3.25	3.0	2.75
	Minimum	3.25	3.0	2 75	2.50
Combined carbon	Maximum	.10	.20	.30	.40
Sulphur	"	.05	.05	.05	.06

These limits are for Group 2, Class X, and there appears to be such a basis already, for a large proportion of the produce of that county falls easily within these limits.

Similarly, for Group 2, Class Y, the limits would be :—

Standards of Purity for English Irons. Group II. Class Y.

P Not over 1.5 per cent.
Mn " " 1.75 "
Nor under .9 "
S (grades 1 to 3) not over .06 per cent.
(grade 4) " " .08 "

transport charges places upon the more distant rival brands. This matter of standards of purity is comparatively simple.

The question of "Standards for Grading" is much more difficult, and the author will now deal with it.

Standardisation of Grades.

It will be generally conceded that the first grade, or first number, of a pig-iron shall be the very softest quality which can be ordinarily manufactured, and also be utilised without special precautions in the foundry. I think that this limit is reached when silicon is between 3.5 per cent. and 4 per cent. Pig-iron containing over 4 per cent. silicon would certainly require special precautions in the foundry—it could hardly be used by itself, and would be valuable chiefly as a "softener," which would permit about 50 to 75 per cent. of *cheap scrap* to be charged with it. Pig-iron containing over 4 per cent. of silicon would demand special working of the blast furnace to produce it continuously. The charges would need to be kept "silicious," also the proporton of fuel and the temperature of the blast would require increasing, thus adding to the cost of production beyond that for common practice. Consequently we may fix the *maximum* limit for the silicon in a No. 1 foundry pig-iron as 4.0 per cent., and this should be the starting point in the system of grading by analysis. The combined carbon which normally corresponds to a silicon content of between 3.5 and 4 per cent. varies from a "*mere trace*" to 0.1 per cent. Therefore the *maximum* combined carbon for a No. 1 grade is 0.1 per cent.—speaking. for the moment, particularly of Group II., Class X. Irons.

But in commercial work we find a slight overlapping of grades; for instance, we occasionally obtain 0.1 per cent. combined carbon in iron containing less than 3.5 per cent. silicon. The averages for long periods, and when working with both large and small deliveries, prove that you cannot rely upon the combined carbon not to exceed 0.1 per cent. unless the silicon is kept above 3.25 per cent. Therefore this fixes the minimum for No. 1 grade at 3.25 per cent., and we may write the particulars as shown in Table No. 7.

"Grading" of Group 2, Class X.

Using the same method of compilation we obtain the values for grades Nos. 2, 3, and 4, as shown in table No. 7.

The sulphur which is here given is the average for the same periods and deliveries as the silicon and combined carbon—you will note it is within the limit previously mentioned.

"Grading" of Group 2, Class Y. "Grading" of Group 3.

For the other groups I have found the following limits apply:—

TABLE No. 8.—"*Grading by Analysis, allowing for 'Over-lapping.'*" *English Irons, Group II., Class Y (High Manganese).* By W. B. PARKER.

Item.	Limit.	No. 1	No. 2	No. 3	No. 4
		Per cent.	Per cent.	Per cent.	Per cent.
Silicon	Maximum	4.0	3.3	3 0	2.75
	Standard	3.3	3.0	2.75	2.5
	Minimum	3.0	2.75	2.5	2.0
Combined carbon	Maximum	.15	.25	.5	.8
Sulphur	,,	.05	.05	.05	.06

TABLE No. 9.—"*Grading by Analysis, allowing for 'Over lapping.'*" *Scotch Irons, Group III. (High Manganese).* By W. B. PARKER.

Item.	Limit.	No. 1.	No. 2.	No. 3.	No. 4.
		Per cent.	Per cent.	Per cent.	Per cent.
Silicon	Maximum	4.0	3 3	3.0	2.75
	Standard	3.3	3.0	2.75	2.5
	Minimum	3.0	2.75	2.5	2.0
Combined carbon	Maximum	.15	.25	.40	.60
Sulphur	,,	.05	.05	.05	.06

The limits for hematite are more difficult to arrive at, because some makers persist in sending "mixed numbers" of the grades 1 to 3, instead of sorting these out, even although specially requested to do so. This is a short-sighted piece of business, for often a genuine No. 1 hematite, with high silicon, is required, and would fetch 5s. per ton more than the mixed numbers.

"Grading" Group 4, "East and West."

Hematite.

Therefore the author suggests the grading given in Tables Nos. 10 and 11 for hematite, but wishes to remark that owing to the confusion caused by the above practice you may find numerous apparent exceptions to these limits in actual practice, but these "exceptions prove the rule"—they are "*abnormal*," although generally permitted and accepted.

repress the practice of accepting "mixed numbers" of hematite iron. Generally speaking, it is very important that foundries combine for the purpose of preventing the continuance of irregularities in the grading of *all* qualities of iron. The limits given above are practically what the author uses, and he finds them favourably received by manufacturers.

Other Attempts to Standardise Pig-Iron.

Other workers have more or less confirmed these results. A very good method of recording which group and class a particular brand belongs to has been devised by Mr. W. H. Pretty, of Bedford. He calls it the "Brand Characteristic, or Curve," and describes its use in his paper upon "The Economic Value of Cast Iron," read before the Manchester Association of Engineers in December, 1904.

TABLE NO. 10.—"*Grading by Analysis, allowing for 'Over-lapping.'*" *Hematite Iron, East Coast, Group IV. (High Manganese).* BY W. B. PARKER.

Item.	Limit.	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	Maximum	4.0	3.25	3.0	2.75
	Standard	3.25	3.0	2.75	2.25
	Minimum	3.0	2.75	2.25	2.0
Combined carbon	Maximum	.15	.25	.35	.5
Sulphur	,,	.05	.05	.05	.06

TABLE NO. 11.—"*Grading by Analysis, allowing for 'Over-lapping.'*" *Hematite Iron, West Coast, Group IV. (Low Manganese).* BY W. B. PARKER.

Item.	Limit.	No. 1.	No. 2.	No. 3.	No. 4.
Silicon	Maximum	4.0	3.25	3.0	2.75
	Standard	3.25	3.0	2.75	2.5
	Minimum	3.0	2.75	2.5	2.0
Combined carbon	Maximum	.1	.2	.3	.4
Sulphur	,,	.05	.05	.05	.06

The question of grading hematite was recently brought forward in a legal contest, the question being: "Do orders for 'mixed numbers' imply a specific composition for the iron?" The answer was "No!"

Well, then, this being so, why allow such a practice to continue? Why not strictly specify the grade required and keep the manufacturers to that? To me it seems that legally there *is implied a specific analysis* when an order definitely calls for a *particular* grade or number. Hence it is better for foundrymen to order specific grades, and to gradually

"Curves for Group 2, Class X."

The author only managed to obtain a copy of this paper during the last fortnight, and could not prepare copies of Mr. Pretty's diagrams to show you, but he has drawn Fig. 1, expressing the specification he quotes for Group 2, Class X., in accordance with Mr. Pretty's method.

Mr. Pretty obtained his charts direct from the manufacturers of the various irons, but, of course, it will be necessary to work out charts independently of the makers, for the reasons already indicated.

Consequences Following Standardisation

We must now glance at a few of the consequences which will follow the general use of specifications.

Firstly comes the question of "Guarantees and Rebates." We cannot say much about guarantees at present, that is, guarantees involving "consequential damages," but I think that if manufacturers will study the subject they will come to the conclusion that they can give guarantees upon certain items. These will probably be confined for some time to the "gradings" only, and *particularly* for the upper and lower grades, because deviations from specifications in these will cause most trouble to rectify in the foundry.

Foundries who work to analyses have to make careful allowance for losses of silicon during melting, and it appears only proper that for an important item such as silicon there should be some system of rebate, to provide for the expense and trouble caused when this falls below standard. Sometimes such a "fall" in percentage has to be rectified by additions of ferro-silicon, which costs about £14 per ton. A "fall" of three-tenths of a per cent. in silicon may be serious, because, together with the loss in the cupola, it would make a total "fall" of, say, 0.5 per cent. to 0.8 per cent. of silicon. This would considerably alter the value and utility of the castings made from the iron if they happened to be required at the top or lower end of the scale common to foundry practice.

Secondly.—When specifications have been decided upon it will be necessary that stocks of iron held in the warrant yards and elsewhere shall be kept and classified in accordance with them. Records of their composition will also be needed for reference, in order to meet the consumers' requirements.

Thirdly.—Cases of dispute as to composition should in all cases be settled by a representative of the suppliers sampling the iron in the presence of the purchaser according to fixed rules. The sample obtained should be divided into two or three portions, so that it can be tested separately by the supplier, the purchaser, and an independent authority, the mean or the two nearest results being accepted as *final* proof of the composition—the loser paying for the independent report. If the metal is not within specification the purchaser should have the option of returning the same, or accepting it at the current price for the grade it corresponds to in composition.

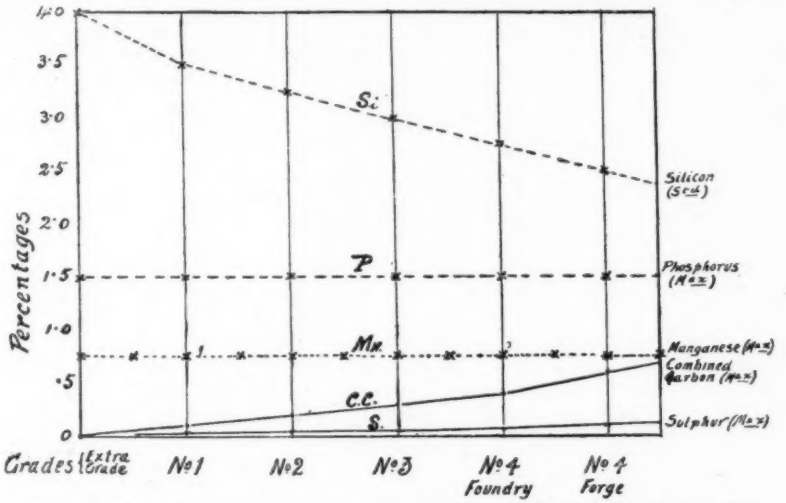

FIG. 1.—COMPLETE SPECIFICATION FOR ENGLISH IRONS OF GROUP II., CLASS X., EXPRESSED AS CURVES ACCORDING TO MR. W. H. PRETTY'S METHOD.

Fourthly.—"*Standardisation of the sampling of pig-iron.*" The system of sampling the author uses is as follows:—One pig is selected at random from each five tons of iron in each delivery. These are fractured into thirds, and a

third of each pig so selected is sent into the laboratory and constitutes what is called the "bulk" sample.

The laboratory then obtains the "assay" sample from them as follows :— The clean fractured surface of each piece is drilled into in six places, as shown in Fig. 2, to the depth of 1 in.

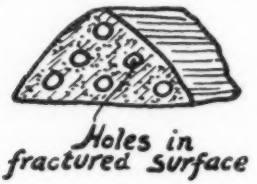

FIG. 2.

A clean (dry) ½ in. diameter drill is used. The drillings so obtained are well mixed, transferred to a dry bottle and labelled. In case of dispute the drillings, after mixing, are divided among the parties concerned, as above indicated. Experience obtained during four years has proved this method of sampling gives very reliable results, and resampling the same deliveries always confirmed the first results.

Fifthly.—Standard samples for comparison :—Probably it will prove necessary to have a system of "Standard Samples," which will be valuable for checking errors etc. in analysis due to incorrect methods being used, or careless working. These should be prepared and issued by the National Physical Laboratory on similar lines to that used in U.S.A.

Sixthly.—Standard methods of analysis :—It will also be necessary to standardise the methods of analysis to be used in cases of dispute. A good deal has been done already in this subject by steel makers, but the results have yet to be applied with particular reference to pig-iron. The author would willingly co-operate with anyone appointed by this Association to deal with this subject.

Conclusion.

Everyone will admit there is a growing need for thorough standardisation of pig-irons for foundry use. In America and Germany the foundry trade has standardised the grading of pig-iron upon a basis of silicon contents only. We in Great Britain must do so in the near future.

But the author hopes to see the matter dealt with in a British manner, not simply slavishly following either American or German methods, because neither of these countries has evolved a really good system. They have left out the important consideration of *combined carbon*, and have not attempted to standardise the "purity" as well as the "grading" of the iron. It is not a question to be hurriedly decided, and it should be worked at in combination with pig-iron manufacturers. While wishing to avoid being accused of calling "peace" where there is "no peace," it must be acknowledged it would greatly redound to the advantage of both manufacturers and users of pig-iron if the manufacturers in the *large iron producing districts* would arrange to standardise their practice and products, upon such lines as indicated above, and the more thoroughly they do it the better.

Debate.

MR. COOK (Chairman) remarked that he had found difficulty in making suppliers of pig-iron sell to specification, but that the limits Mr. Parker had just given were so liberal that there appeared no reason why makers should not work to them. At present he bought "to samples submitted." He would like to hear what Mr. Parker could suggest as a remedy for a trouble being continually met with in cylinder castings as per sketch. The hole produced at point indicated was probably a "draw-hole," and the irons used in the mixture had the composition :—

	A. Per cent.	B. Per cent.
Silicon	2.25	1.0
Manganese	.40	1.8

MR. LONGMUIR remarked that the question of specifications for foundry pig-irons is a most important one, and it should be taken up at once by blast furnace owners in conjunction with foundrymen. He had recently had an instance of very irregular composition in some East Coast (Bessemer) hematite, which proved to contain 0.15 per cent. of sulphur. This shows how important it is that makers should test their products, and also that foundries should work to a specification for "purity" of irons. He had some doubts as to the advantages of using the irons sold as refined, or special (which Mr. Parker has placed in Group 1), there seemed no real need for them since hematite and genuine cold-blast irons are available. He thought that 1.5 per cent. was a very fair maximum limit for phosphorus.

MR. MASON said his difficulty in buy-

ing pig-iron was the necessity of working through a purchasing department, who did not know enough about foundry requirements to be able to appreciate any difference between various pig-irons except the difference in price. Consequently he often had to use just what was sent him, whether it was suitable or not, just because it was cheap.

He also thought there appeared no advantage in buying so-called "refined" irons, and it was not at all clear whether they were genuinely made "pig-iron." He asked if the test-piece, fractures of which had been shown, had been fed at the gate? He would like to know definitely whether manganese itself was a "softener" or not? Also, he wished to hear for what reason ferro-silicon at £14 per ton was used instead of a specially silicious pig-iron? In working with ferro-silicon was there not a risk of greater loss in the cupola?

With respect to the sketch on board, he had often noticed that the iron which first ran out of the cupola gave more trouble than that which was tapped later —why was this so? Also, why was the maximum for phosphorus placed at 1.5 per cent.—were there no circumstances in which a higher percentage might not be advantageous? What was Mr. Parker's objection to chilled, machine-cast, pig-iron? Was it because the re-melting in the cupola did not reconvert it into grey?

Professor Turner remarked that the limits given by the lecturer coincided with his own experience, but he thought that the sulphur limit of 0.05 per cent. for Grades 1 to 3, as shown in the "Specifications of Purity," was rather too liberal, as he found that usually No. 1 grade contained 0.03 per cent., No. 2 contained 0.04 per cent., and No. 3 0.05 per cent. of sulphur.

With reference to the standard samples, there already existed a splendid set of standard steels prepared by the British Association, and these were in his keeping, and he would supply samples of the same to anyone requiring them if they would remit the cost of postage with their order.

He believed he was the first person to use a curve or chart to illustrate the grading of pig-irons; anyway, he gave a chart on page (43) of his book on "Iron-Founding," showing the grading of "Cleveland Pig-Iron." He suggested the use of chills to prevent the "drawhole," and said the first metal tapped usually contained more sulphur than subsequent tappings, owing to it having laid upon the bed of coke, and the high sulphur hardens the iron and tends to cause "holes."

Mr. Hailstone gave an instance of the variation of sulphur in pig-iron, according to the position at which is was drilled thus :—

				Drill Holes.
Hole No. 1	yielded	.11	per cent.	of sulphur.
„ No. 2	„	.037	„	„
„ No. 3	„	.074	„	„

The latter result is practically the mean of the other two results, the peculiar point being that the lower part of the pig contained more than the top, which is contrary to common experience. Could Mr.. Parker explain this? He had also recently had a case of high sulphur in hematite iron, almost identical with Mr. Longmuir's experience, and had rejected the material.

Mr. Parker, in reply, said that quite a number of manufacturers were now working to his specifications, and that the way to introduce this system generally was for foundrymen to "stand firm" and not allow irregular metal to be palmed off on them as "good," nor even at the same price as the correct article.

In some cases makers replied that "individual orders are too small to work to specification"—but this objection was removed by standardising the products of the district, as indicated in the lecture. Some makers simply replied that they "*did not sell to analysis;*" such replies were almost always from people who did not employ chemists. When chemists were employed the replies were all in favour of standardisation. Small foundries who could only take small deliveries could overcome the above objections if they would agree to "pool their orders"—that is, by co-operating and starting a stock yard between themselves at some convenient central place. Then they could place larger orders for the main qualities they used, with the condition that the metal was "*to be in accordance with specification.*"

A fruitful cause of trouble when buying to analysis was the lack of technical knowledge on the part of the agents for the irons, who, in many cases, had merely "business qualifications," and knew very little, if anything, about the material supplied.

It was no wonder such sellers could not sell to analysis. The way to overcome this trouble when met with was to ignore the agents, and deal direct with the makers of the iron. This would undoubtedly be greatly to the advantage of both makers and users.

Of course, the chief objection the makers had to grading by analysis was that it necessitates employing a chemist instead of a labourer—that is, skilled labour as against unskilled, but whereas a good chemist would be saving the manufacturer from the troubles and losses he now experiences (owing to rejections of his iron by customers who are buying to analysis) the *labourer could not possibly save him this.*

In fact, it was the impossibility of the labourer to tell the true grading of the iron by "fracture" that caused these troubles and losses.

Respecting the sketch on the board, the most obvious way to overcome the trouble would be to place a runner or riser at the point where the draw-hole formed—a dummy riser might do. Judging from the analysis of the irons used in this casting, he suggested the manganese should be kept about 0.6 per cent., and the silicon from 1.75 to 2.0 per cent.

The most probable reason why the first metal gave more trouble than later tappings was that the bed of coke was skimped, and, consequently, the metal was colder—that is, too cold for the size of the casting to be poured.

Respecting Mr. Longmuir's and Mr. Hailstone's remarks, there was no excuse for the high sulphur in hematite—it was an irregular product, and should be treated and *priced* as such by the manufacturers, and he was glad to hear it had been rejected. There is no doubt that a buyer had a right to be supplied with a definite composition of iron when he specified a particular grade and make like hematite—it was a common law right.

Respecting Mr. Mason's and Mr. Longmuir's remarks, *re* "special refined" irons, it is the author's personal opinion that during the next ten years these irons will disappear from the market, for in some cases they were certainly not genuine pig-irons. Moreover, with hematite, genuine cold blast, Swedish iron, and steel scrap, together with the ordinary foundry pig-irons, there is available all the necessary means for meeting every demand likely to occur in foundry practice.

"All-mine" hot-blast pig will also disappear in time, because it fills no definite want, and is unnecessary. The test bar shown had been thoroughly well fed, and was cast on end.

The value of ferro-silicon, compared with *impure* high silicon pig-iron, lies in the fact that often only the silicon required correcting, the sulphur phosphorus and manganese being correct. In such a case the use of an impure silicon pig-iron (usually very high in phosphorus) would throw some of these elements out of specification, and then the remedy is worse than the evil; but by using a 30 per cent. ferro-silicon no important alteration in phosphorus, sulphur, and manganese will occur. The ferro-silicon is really as cheap to use, because only a few pounds are required per charge, as compared with a hundredweight or more of the silicon pig.

The loss in silicon when using ferro-silicon is not higher than usual; it generally runs 0.25 per cent., but depends somewhat upon the way it is charged. It should be put in the middle of the charge as near as possible. There is no advantage to be obtained with phosphorus over 1.5 per cent., and the speaker has not met with castings containing higher percentage except in children's toys, ornamental castings, and such like work, into which it is to the advantage of the maker to put such very brittle metal, because it increases the breakages, and, indirectly, his orders. For ordinary foundry work the phosphorus must not exceed 1.5 per cent., and should usually be lower. Manganese itself is never a "softener," but if the mixture is high in sulphur then by indirect action upon the sulphur it acts as a softener. That is, it removes a good portion of the sulphur as manganese sulphide slag, Mn S, thus reducing the *two* hardening elements, manganese and sulphur simultaneously. With regard to Professor Turner's comments, the sulphur stated in the tables is the maximum sulphur found, and allowable, in the first four grades. It is true No. 1 and No. 2 grades usually contain less than 0.05 per cent., but so long as the sulphur does not exceed 0.05 per cent. it is not (except in special instances) necessary to specify any lower than 0.05 per cent. The credit for the originality of the curves did not occur to the speaker, as he had not noticed the curve on p. 43 of Prof. Turner's book, although he has had a copy of it for some time; he regretted the oversight.

With respect to the curious instance of irregular distribution of the sulphur in pig-iron, quoted by Mr. Hailstone, it would be of interest to estimate the manganese at the same points to see if there was any connection, because usually the manganese if sufficiently high carries the sulphur to the top, and not the bottom,

of the pig. It is an example of the necessity of sampling pig-iron in accordance with the method used by the speaker; this method would average up such differences, and after all it was the average sulphur content which was taken into account when calculating out cupola mixtures.

With reference to Mr. Mason's question *re* use of chilled (machine-cast) pig-iron,—if the silicon was over 3 per cent. the remelting in the cupola might convert the bulk of it into "grey" metal; but even if it did, the percentage of combined carbon in such metal was not, in the speaker's experience, as low as in the same metal which had been manufactured into sand-moulded pig—that is, the metal never recovered the softness which normally belonged to its composition, probably because the temperature of the cupola was insufficient, and the heating was not so prolonged as in the blast furnace, therefore chilled pig-iron must be avoided when requiring soft metal in the castings.

The vote of thanks was then given, and responded to.

——o——

In brass rolling mill practice in which crucibles are used and great care has to be exercised in maintaining mixtures, the loss of spelter in making yellow brass runs from 1 per cent. to 1.5 per cent. It often happens that the loss may be kept down to less than 1 per cent., but this usually means that the brass is poured at too low a temperature and the resulting metal is not good.

In brass foundry practice the loss of spelter is usually greater than in the brass rolling mill. The mixtures do not have to be guarded so carefully and the grade of help is not as good. It is unusual to find the loss of spelter in the brass foundry, when yellow brass is melted, less than 3 per cent. It frequently rises to 5 per cent., and if care is not exercised in removing the metal from the fire as soon as the right heat has been reached, the loss will often run as high as 10 per cent. From observations extending over quite a period, we believe that the average brass foundry practice in melting yellow brass is a loss of from 3 per cent. to 5 per cent. of spelter. If considerable scrap is used and now and then small quantities of chips a loss of this amount cannot be called bad practice.

A SOUTH GERMAN LABORATORY.*

By C. C. Macpherran.

Much of late has been said in comparison between the American and European methods in foundry laboratories and foundry practice, and yet when all the conditions are known I think there is as much difference in the practice in different parts of America as in the practice of America and Europe. It is in all cases an adaptation to the existing conditions.

The time allowed has more to do with the difference in chemical methods than has any other condition; even as the price of labour has much to do with the practice in the foundry. We say that the German chemists are very accurate but slow, and there is much truth in that. The American would like to be as accurate, but is seldom allowed sufficient time to be absolutely sure. He must combine speed with what may be termed "practical accuracy." I will give here a brief description of a laboratory in South Germany, of which, for a time, I had charge.

The laboratory was one step up from the street, with cement floors throughout, each room draining off to a sewer connection in one corner for convenience in washing out. Next to the laboratory proper was the office and scale room, and beyond the testing and preparation room. This proved to be a very convenient arrangement.

The samples were brought in by the laboratory sampler, worked up, placed in envelopes, labelled and handed to the chief. In iron, the laboratory usually determined the Si, P. Mn and S and rarely C. C. and Graph. C. The Si and P were worked together. The sample taken up in HCl, HNO_3 run slowly to drynes, taken up again in HNO_3, diluted, filtered and washed. The residue on the paper reserved for Si and the filtrate used for P. Sometimes by Emmerton and sometimes gravimetrically for a check.

The Mn is usually done by Volhardt's method.

The C by the chromic acid method.

The S by Ledebur's method, which is the evolution of the H_2S by HCl in a flask having a condenser in the neck, so that the contents may be boiled without danger of the HCl coming over. A stream of CO_2 is run through to ensure the passage of all of the H_2S and to prevent oxidation. The S is caught in a solution of cadmium

* Paper read before the American Foundrymen's Association.

acetate. The Cd replaced by Cu on addition of $CuSo_4$ solution. The CuS is filtered out, washed clean, the paper burned off at a low heat and the residue weighed as CuO, the S to be calculated from the CuO. The coke is worked for ash and sulphur. The S by Eachkas' method.

German cokes as a usual thing are not so good as our own coke. The by-product coke is much the same, but the natural coke runs much higher in S and ash (S .90 to 1.25 and ash 13. to 15.), and is a dirtier, smaller coke than our better grades.

The cupolas in South Germany are of so many kinds and shapes that I will describe only one type which we used to good advantage, and which was in pretty general use in the country round. This cupola lined to 40 in. diameter straight down to 25 in. above the main tuyere where the bosh wall began, running in to 32 in. diameter at 2 in. above the tuyere and thence straight down to the bottom. The upper tuyeres were eight round pipes $1\frac{1}{4}$ in. diameter run through at the top of the bosh wall, pointing downward at an angle of 30 degrees.

The main tuyere was an opening $2\frac{1}{4}$ in. high, running all the way around the cupola and was about 16 in. above the bottom. This was an average size for that section, the tendency being rather toward small cupolas and several of them, in place of one cupola of very large size. This may not seen economical, but they find it very satisfactory.

This cupola melted iron for the year I was there at a rate of between 4 and 5 tons per hour, furnishing very hot iron at a fuel ratio of 1 to 9.75. This was done with coke inferior to our best Connellsville and the writer is not much of a believer in big fuel ratios either.

The irons used in the foundries were principally three brands:—

Lilleshall Lodge	Si. 2.00 to 3.00	S.	.050 to .13
	P. 1.25 to 1 75	Mn.	.60 to 1.00
Luxemburg ...	Si. 1.50 to 2.50	S.	.050 to 1.50
	P. 1.25 to 2 00	Mn.	1.00 to 1.50
Krupp Bessemer	Si. 1.50 to 3.00	S.	.020 to .03
	P. .10	Mn.	.75 to 1.25

The mixtures were figured down to three standard irons, with some specials which were only cast occasionally, such as chill irons, etc.

The three standard mixtures used were as follows:—

Analyses of Castings.

Cylinder iron ...	Si. 1.50 to 1.60	S.	.100 to .140
	P. .60 to .70	Mn.	.70 to 1.00
Fly-wheel iron	Si. 1.90 to 2.00	S.	.115 to .150
	P. .90 to 1.10	Mn.	.60 to .80
Common iron ...	Si. 2.25 to 2.40	S.	.100 to .130
	P. 1 00 to 1.30	Mn.	.60 to .80

The strength of bars cast from these irons, reduced to our standard (1 in. by 1 in. by 12 in.), were as follows:—

Cylinder iron	...	2,800 to 3,000
Fly-wheel iron	...	2,500 to 2,800
Common iron	...	2,000 to 2,300

The quality of the iron was good, machined easily, finished clean, and held steam well. The riser heads on finished work are higher and heavier than ours: the moulds are more freely vented and the gates and runners larger.

Nearly all work of special type, all of it over two to three hundred pounds, is made in dry sand and the larger pieces in the floor; except the cylinders. Very heavy pieces are made in loam as here. None of the big work is anchored or clamped. All of it is weighted.

The sand is a mixture made at the plant. A rather coarse sand, which has considerable iron and almost no clay, is the base; to this are added fine sand from another bank and clay, in proportions fitting it for the different grades of work in which it is to be used.

Piece work is almost as well paid there as here, but the men there seem satisfied with a little more than half what would satisfy an American moulder.

Machine moulding, when I went there, was not directly in favour, but with the introduction of the convenient, light, handy American machines, came a change of opinion, and when I left we had quite a battery at work on stock pieces for their farm implements and smaller engine pieces.

——o——

IMITATION MANGANESE BRONZE.

MANGANESE BRONZE is a difficult alloy to make, and those who use but little of it had better purchase it. The mixture is so susceptible to a slight increase or decrease of the ingredients that extraordinary care must be exercised in order that the exact proportions shall enter the alloy.

There are many instances, however, in which a strong alloy is needed, but the requirements are not severe. A metal intermediate in strength between manganese-bronze and gun-metal may be required. In such instances the following mixture will,

according to the "Brass World," give excellent results:—

	lbs.
Copper	55
Zinc	43½
Tin	
Aluminium	½

FIG 1.

This mixture is very tough and strong, and will give nearly as much strength as a good manganese bronze. For many classes of work it may be used to replace manganese bronze. A recent use of this mixture is in the making of small propellers for launches. Heretofore, composition has been used, but the preceding mixture will be superior in strength and much cheaper. In other words, a better propeller can be made at less cost. This mixture has every appearance of manganese bronze, and must be treated like it. The castings cannot be distinguished from genuine manganese bronze, and in many instances it is being sold as such.

——o——

THE LEEDS ENGINEERING AND HYDRAULIC COMPANY, LIMITED, have removed to Rodley, near Leeds.

LOCO. WHEEL CENTRES.

By W. P.

IN making an iron pattern for a wheel centre it is not necessary to make a complete wood pattern. Two arms, with a portion of rim and boss, will be found quite sufficient, saving a considerable amount of time and material, and especially so as regards the larger sizes. If the wheel centre is required with the crank pin boss it will be necessary to have two extra arms, but these only need be long enough to take the remaining portion of the boss, as shown in Fig. 1.

FIG. 3.

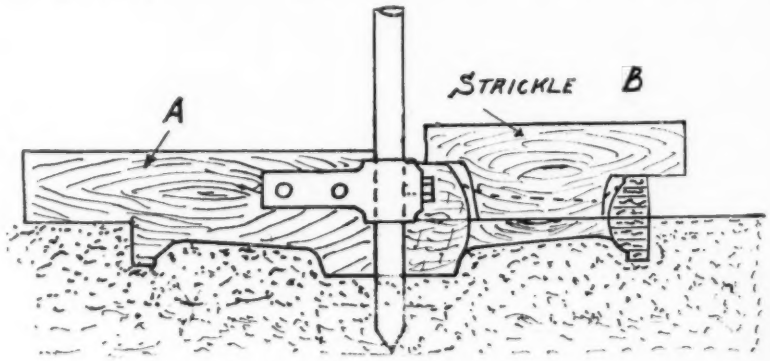

FIG. 2.

The pieces forming the boss must be made detachable, as they must be taken off after the first operation. The dotted lines show the extra pieces for crank pin boss.

A bed is first made from a board A, shaped as in Fig. 2, which corresponds to the bottom half of the wheel: machining is allowed for on the rim and face. The segment pattern is then fixed to the spindle, and rests on the bed already made. The sand is then filled in and rammed between the arms, the required height being obtained by the use of a strickle B, one end of which works on the boss, the other end on the rim, Fig. 2. The pattern is then raised up

and the pieces forming the crank pin boss taken off. The pattern is then moved round the distance of one arm, the second arm then fits into the mould formed by the first arm, the space between being filled in and strickled off as before. This operation is repeated until all the arms have been rammed up.

If there is a wheel moulding machine in the shop the work could be done on it, the moving of the arms being done by the dividing wheel. In either case it is very necessary that the arms be set out accurately, otherwise there will be overlapping of the arms when the two halves are put together. The excess of metal in the boss is taken out with a lightening core, leaving about an inch of metal all round. In preparing the cope, which will have a plain, flat surface, it is advisable to have it slightly concave in order to prevent the risk of crushing.

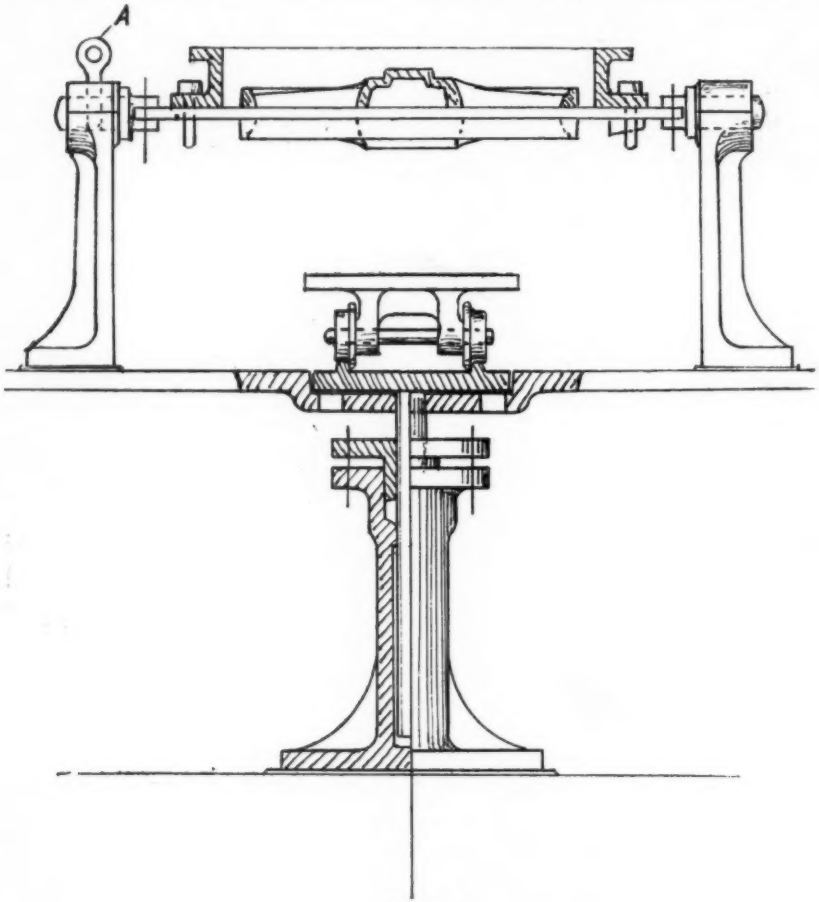

FIG. 4

The reverse half of the iron pattern is made by turning the segment upside down, repeating the former process on a bed made by a sweep board corresponding to the shape of the arms on the top.

After being cast, the faces of the two

halves are machined level and put together, adjusting the arms one with another, so that as little chipping as possible will be required through the overlapping of the arms. They are then cramped together, and four ½-in. holes bored right through the rim, the holes in one half are then tapped out, and four dowel pins screwed in. The whole pattern is then turned up on the outside, and top and bottom of the rim, the inside with the arms and boss being finished off by hand chipping and filing.

To make an iron pattern in two halves from a wood pattern which has been made all in one is a comparatively simple job, but it must be remembered that if the pattern has been made with only the ordinary contraction allowed, it will be necessary to line up the outside of the rim to make up for the extra iron contraction and machining required. This will make the rim so much thicker than it ought to be, according to the size of wheel; for instance, in a wheel, say, 5 ft. diameter, the difference will be ¼ in. In some cases this extra thickness would not be considered detrimental, but if it is necessary to have the rim correct, it can be made so by a making-up piece made of a segment of the required section of rim with short portions of two arms, Fig. 3.

To make the mould the pattern is bedded in the floor in the usual way, but the joint is made by means of a strickle the same shape, and used in the way as described, and shown in Fig. 2.

Making the Moulds for Steel Castings

As already stated, these may be made either by the ordinary moulding methods or by machine plate moulding; the advantage of the latter process is a considerable reduction in the cost, for under competent supervision what may be termed unskilled labour can be employed, in addition to the saving of time in the moulding.

A sketch of a simple machine for the purpose is shown in Fig. 4. This machine is not only simple, but is also efficient, and costs very little to make.

The sketch (which is not drawn to any scale) shows the principal features, and requires very little explanation as to how it is worked.

One half of the pattern, either wood or iron, is cramped to the plate, and the holes which are already in the pattern are continued through the plate so that when the other half is put on the opposite face they will be exactly in line with each other. The holes to correspond with the pins in the moulding boxes must also be accurately drilled, and the pins turned to a good fit. The fixing of the pattern and the arrangement of the boxes on the plate must be done very carefully, as it is quite obvious that unless these are accurate the wheel, when cast, will not be correct.

The method of working the machine is as follows:—After the box is rammed up the steady pin in the trunnion A is taken out and the plate allowed to swing over. The bogie is then run on to the plate, which is attached to the hydraulic ram. The bogie, by means of the ram, is raised up to the box, the cotter pins knocked out, and after a little rapping with wood mallets, the ram is lowered with the box on the bogie. Repeat the operation for the other half of mould.

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VOLUME AND TEMPERATURE CHANGES DURING THE COOLING OF CAST IRON.*

By Professor Thomas Turner, Assoc.R.S.M.

It is a matter of common observation that some metals or alloys fill a mould better and take sharper impressions than others; pattern-makers are aware that the allowance to be made for shrinkage varies with the kind of metal and the shape of the casting; while it is generally known that solid grey cast iron floats before it melts when it is thrown upon a fluid bath of the same metal. These facts are connected with the contraction, expansion, shrinkage, or other volume change, or changes, which take place while metals solidify and afterwards cool to the temperature of the air. The whole subject is of great practical importance, and of no little complexity, although, in the United Kingdom at all events, it has not hitherto received the attention which it deserves.

According to R. Mallet, it has been stated on various degrees of evidence that certain metals expand in volume at or near their points of consolidation from fusion, and "Réamur appears to have been the first who gave currency to the statement that cast iron, bismuth, and antimony all expand on solidifying." Mallet also, in the same paper, quoted, from Kerl, the statement that cast iron

* Paper read before the Iron and Steel Institute.

"contracts in such a manner that at the commencement of its solidification it first expands so as to be able to fill up the smallest depressions and cavities of a mould, but after solidifying it contracts." Mallet himself, however, took an opposite view, and conducted a series of experiments in which conical wrought-iron vessels of known volume were filled with iron at its solidifying point, and its relative density, when in this condition, was calculated. These vessels were of considerable size, being 2 ft. high, 1.5 ft. wide at the base, and had an open neck 6 in. in diameter. Mallet concluded that although there were grounds for assuming that bismuth does expand on iron of projectile quality, and the volume was measured by means of finely graduated steel-beam calipers. So little, however, was Mallet prepared to expect that solidified cast iron would expand that he argued at considerable length (pp. 224, 225), to prove that the bend shown at A on his curve was an anomaly, and that the true shape of the curve was as shown by the dotted line. This is a notable instance of the true facts being overlooked on account of their unexpected character.

In 1875 Roberts-Austen* employed Mallet's method for the determination of the density of silver at the point of solidification, but the method was not

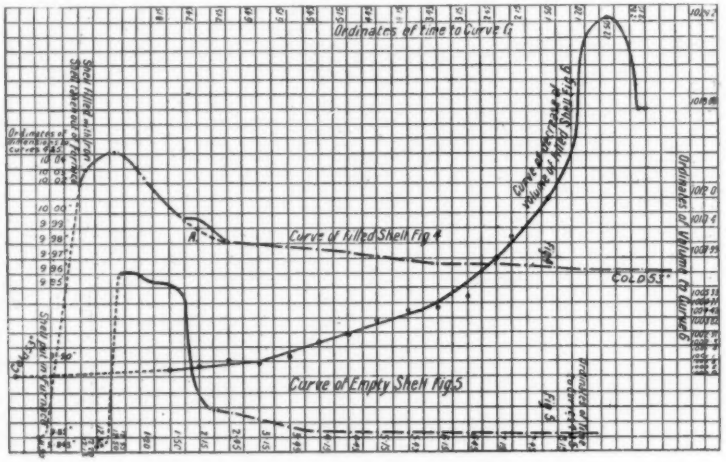

FIG. 1.

solidifying, the evidence was insufficient in the case of other substances supposed to do likewise. Although Mallet argued strongly against the view that cast iron expanded during solidification, it is a remarkable fact that as a result of one of his experiments, conducted at the Royal Arsenal, Woolwich, a curve was plotted on which are distinctly shown the three elevations which are now recognised as being characteristic of grey phosphoric cast iron. This is shown in the curve marked Fig. 4 on the accompanying diagram (Fig. 1), which is reproduced from the original paper.* In this experiment a red-hot hollow spherical cast-iron shell was filled with fluid cast

capable of any considerable accuracy. In 1879 Wrightson† described his "tektometer" to the Iron and Steel Institute, and gave particulars of its use with fluid cast iron. The instrument consisted of a floating metal ball attached to a recording spring balance. Roberts-Austen and Wrightson subsequently conducted researches with various metals,‡ using Wrightson's instrument, and concluded that while the density of bismuth decreased on solidification, the other metals contracted, the relative values being:

* "Proceedings of the Royal Society," vol. xxiii. 1874, p. 222.

* "Proceedings of the Royal Society," vol. xxiii. 1874, p. 481.

† "Journal of the Iron and Steel Institute," 1879, No. II. p. 441.

‡ "Philosophical Magazine," vol. xi. 1881, p. 295; vol. xiii. 1882, p. 360.

bismuth, —2.30; cast iron, +1.02; tin, +6.76; copper, +7.10; lead, +9.93; zinc, +11.10; and silver, +11.20. This form of apparatus is, however, only available so long as the metal is sufficiently fluid to allow the ball to move freely, and is incapable of indicating what takes place at or below the point of solidification.

With the application of scientific methods in the large iron foundries in America, dating from about 1885, special attention was paid to the shrinkage of cast iron, and about this time W. J. Keep introduced his now well-known method of measuring shrinkage, in a 12-in. bar, by means of a graduated wedge inserted between the end of the cold bar and the chill in which it was cast. Though this simple form of test is of great value to the practical man, on account of the ready control it allows of foundry mixtures, it gives merely the algebraic sum of the expansions and contractions which have taken place, and does not permit of their differentiation. To overcome this difficulty, Keep, Moldenke, and West have introduced forms of apparatus for observing the changes of volume of a cast bar from the moment it begins to solidify until it reaches the atmospheric temperature.

Keep's apparatus, and the valuable conclusions deduced from its application, have been fully described in the "Journal" of this Institute.* It consists essentially of two steel pins which enter near the ends of a sand mould in which the test-bar is cast. These pins engage arms which work on pivots on the edge of the flask; the outer ends of these arms move ten times as far as the pins in the test-bar, and their motion is recorded on a rotating drum. Mr. Keep's whole paper is full of most useful information, but perhaps the most important facts are represented in Fig. 2, which shows the three expansions which are characteristic of soft grey phosphoric iron. In the same diagram the proportion of combined carbon is also given. The subject was discussed at considerable length in America, particularly at the Congress on the Physics of Cast Iron held at Pittsburg in 1896, and marked differences of opinion appeared to exist between Messrs. Keep and West. These were probably due to the different definitions adopted for "shrinkage" and "expansion," as it is scarcely conceivable that such experienced practical men as those named could differ as to the obvious facts.

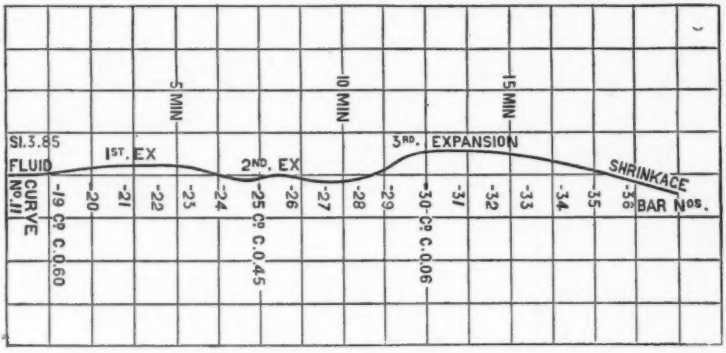

FIG. 2.

The one marked omission in Mr. Keep's paper was that no temperature determinations were made, but this was, to some extent, remedied by the contribution made by Mr. Osmond to the discussion. Mr. Osmond referred to his observations on the temperature retardation which took place at certain intervals during the cooling of iron,* and suggested that the first expansion might take place at about 1,100 degrees C., where the greater proportion of the graphite separates. The second expansion would only be observed in phosphoric iron, and

* "Journal of the Iron and Steel Institute," 1895, No. II. p. 227. See also Keep's "Cast Iron"—an excellent book.

* "Annales des Mines," 8th series, vol. xiv. 1888, pp. 39 and 81.

would occur at about 900 degrees C.; while the third expansion certainly occurred at Barrett's point of recalescence, and might be expected at about 700 degrees C. Mr. Osmond, however, pointed out that these temperatures might vary somewhat considerably with the chemical composition of the metal and the conditions of the experiment. It may be added that in 1903, at my suggestion, my colleague, Mr. O. F. Hudson, determined the points of retardation in a sample of No. 1 Northampton pig-iron, and found them to be respectively 1,115 degrees C., 935 degrees C., and 860 degrees C. The first of these values agrees very closely with

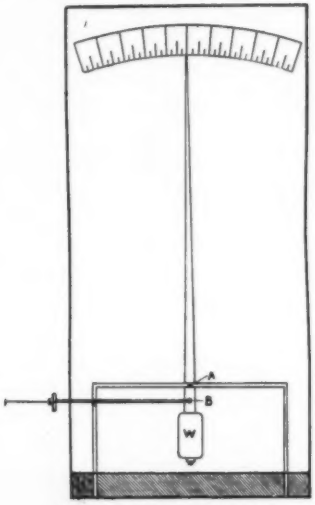

FIG. 4.—EXTENSIOMETER.

Mr. Osmond's prediction, but the other temperatures were, in this case, higher than he anticipated.

As the changes which take place during the solidification and cooling of cast iron are of great practical and theoretical importance, it appeared advisable that further study should be made with accurate apparatus and typical materials. For this purpose a special and simplified form of apparatus was designed in order to measure the changes of length of the test-bar; while cooling curves were taken of the specimens at the same time by means of the Le Chatelier pyrometer.

While Keep's apparatus is a marked advance on anything before attempted, and admirably suited to its purpose, it was felt that the autographic record, which for works purposes would be invaluable, was not the best for a series of experiments where it might at any time be necessary to devote special attention to a particular part of the curve. Naturally, an autographic apparatus, unless arranged to run at various speeds, gives the same space for each time interval whether that interval be of special importance or not.

The form of apparatus ultimately adopted by the author, after various trials, may be described as consisting of three portions: (*a*) the mould with the test-bar; (*b*) an arrangement for indicating changes of length in the bar; and (*c*) the pyrometer. The experiment was that of casting a bar in a sand mould; keeping one end of the bar fixed, and noting the alterations in position of the other

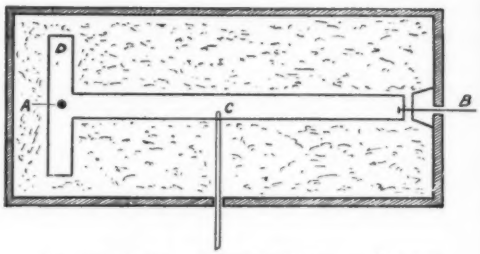

FIG. 3.—PLAN OF LOWER HALF OF MOULD.

A. FIXED VERTICAL PIN.
B. MOVABLE HORIZONTAL PIN.
C. THERMO-COUPLE
D. POSITION OF GATE.

end, which was left free to move. At the same time a thermo-couple was introduced into the mould so as to indicate the temperature.

The form of test-piece and method of working will be understood from Fig. 3, in which is given a plan of the lower half of the sand mould, with everything in place for receiving the metal. In order to ensure that the one end of the bar does not move, the casting is made in a T form; and, to make assurance doubly sure, a short steel pin enters vertically at A, and is clamped above to the end of the iron box containing the mould. The metal solidifies round this pin as it cools, so that movement at this end is prevented. At the other end a thin fin of sand is left, just sufficient to prevent the flow of the metal when fluid, but not enough to appreciably interfere with the free movement of a solid bar. Passing

through this fin in a horizontal direction, and continuous with the centre of the bar, is a metal pin which, as a matter of fact, consists of a wire nail, as the head is of a convenient shape and size for the purpose. The bar is ½ in. in square section, and exactly 12 in. in length from the cross-piece to the head of the nail, and when the metal is poured into the mould it surrounds the head of the nail, which thus becomes firmly embedded. It is, however, quite free to move, with the bar, in a horizontal direction, and its outer end is attached to the indicating apparatus or extensiometer.

The special form of extensiometer designed for these experiments is shown in Fig. 4. It consists of a brass pointer 28 in. long, which is supported so that it swings freely, but it is kept at rest in a vertical position by the weight W, except when it is deflected during the progress of an observation. The weight ensures that the pointer shall follow the slightest movement of the test-bar, whether positive or negative. In the apparatus actually employed the movement of the end of the bar was multiplied about forty-fold, but that is a detail which could obviously be varied at will by altering the distance between the point of support (A) and that of the attachment (B) to the thin rod which connects the end of the test-bar to the lower end of the pointer. As a matter of fact, our instrument was provided with two attachments giving different magnification, but a forty-fold increase was, on the average, found most convenient for the present series of tests, and with this apparatus.

The pyrometer used was the ordinary Le Chatelier thermo-couple, which was placed bare in the mould so as to be in actual contact with the metal, and the scale divisions from the beam of the galvanometer mirror were read by the eye. For each experiment, therefore, three persons, at least, were necessary: one to record the readings of the extensiometer, another to read the pyrometer scale, and a third to pour the metal into the mould, and give the signal to start observing. Time signals were given by hand-tapping each five seconds during the early part of each experiment, the intervals being later increased to ten seconds, and ultimately to twenty or thirty seconds as the metal is cooled. We were thus able to ensure the absolute agreement in time of the expansion and cooling curves which could not otherwise be so readily obtained.

The whole of the pyrometric work was conducted by the Lecturer in Metallurgy, Mr. O. F. Hudson, R.R.C.S., who has also reduced the original curves for the purpose of reproduction. The curves which have been prepared only give about one-third of the whole time which was actually observed, but the parts which have been omitted merely show uniform and normal cooling. The expansion observations were made by Mr. T. W. Picken, who is now in charge of the testing department of the works of the Daimler Company, Coventry, but who was at the time Bowen Research Scholar in the University of Birmingham. The extensiometer used in these experiments was actually constructed by Mr. Picken, during a vacation, from rough sketches supplied by the author. Since Mr. Picken left the research has been continued by Mr. F. D. Simpson, the present Bowen Scholar.

It will be seen from an examination of the accompanying diagrams that the curves obtained may be divided into four classes, depending upon the number of arrests which are observed in the normal rate of contraction of a cooling solid. The curves given may be regarded as being typical, but a large number of observations have been made with various metals and alloys. The actual shape or slope of curve obtained from a particular material will depend to some extent upon the rate of cooling, and this is affected by the pouring temperature, the size of the bar, and the condition of the mould. But though the curve may thus differ in form, within certain limits, the type always remains the same for similar materials, and it is possible, at a glance, to distinguish the type to which the metal belongs. These types are represented in Fig. 5.

1. In the first class of material the contraction curve is uniform, and there is no arrest in the decrease of volume as the metal cools. This is represented in the lowest curve on the diagram, viz., that given by pure electrolytic copper. Aluminium, antimony, lead, tin, and zinc yield curves of this type. Mr. Simpson has also found that the alloys of zinc and aluminium belong to this class, though it has been stated that alloys of this series expand during solidification. It is proposed to publish the results of these researches in due course.

2. The second class of curve affords indications of one retardation during contraction, which may or may not lead to an actual expansion. White iron is a typical example of this class, to which

also (as Mr. Keep has shown) high carbon steel belongs. It may be interesting here to note that Mr. Simpson's experiments have shown that the zinc-copper alloys belong to this type. Many of the zinc-copper alloys expand during solidification, and some members of the series in an extraordinary manner. So far as I am aware, this is a new and important observation, but details of such tests scarcely come within the purview of this Institute.

3. The third type of curve indicates that two arrests have occurred in the rate of contraction, and non-phosphoric grey cast iron furnishes an excellent example of this class. Grey hematite gives two marked expansions, one occurring immediately after the metal has become sufficiently solid to cause the indicator to move, and the other after an interval of nearly three minutes, when a ½-in. square test-bar is employed.

4. The last class of curve is represented at the top of the diagram, and in this three distinct arrests occur. A very grey phosphoric pig-iron gives the most characteristic curve of this type. The second expansion is relatively small in amount, and though the first expansion is large, it is not so very pronounced as the third expansion; while, as a result of the three taken together, no less than four minutes and thirty-five seconds after solidification has elapsed with a ½-in. square bar before it has again reached the original size of the mould, after which contraction proceeds regularly to the atmospheric temperature.

It is now proposed to give particulars of the contraction and temperature changes of a few characteristic examples. For this purpose the following materials were selected:—

1. *Pure White Cast Iron.*—The tests were performed on a sample of "American Washed Iron" which is kept as a base for tests of the influence of various elements. It consists of practically pure iron, with about 3 per cent. of combined carbon.

2. *Non-Phosphoric Grey Iron.*—For this purpose a No. 3 hematite pig was employed; it was part of the stock used for steel melting in the open-hearth furnace in the smelting laboratories of the university. It was somewhat higher in silicon than usual, but this was not in any way an objection for the purposes of these tests.

3. *Phosphoric Grey Iron.*—The sample tested was a No. 1 Northampton (Islip)

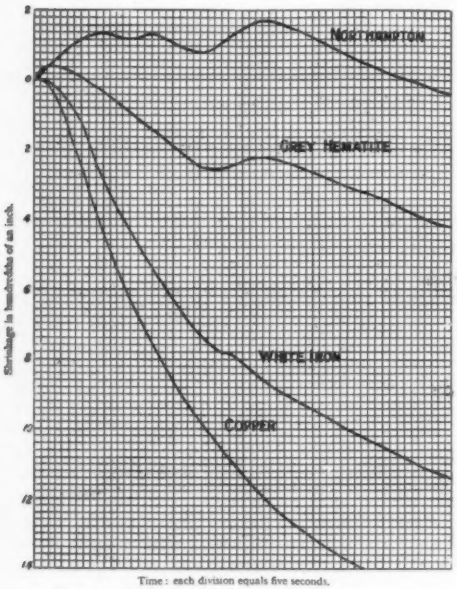

FIG. 5.—TYPES OF CONTRACTION CURVES.

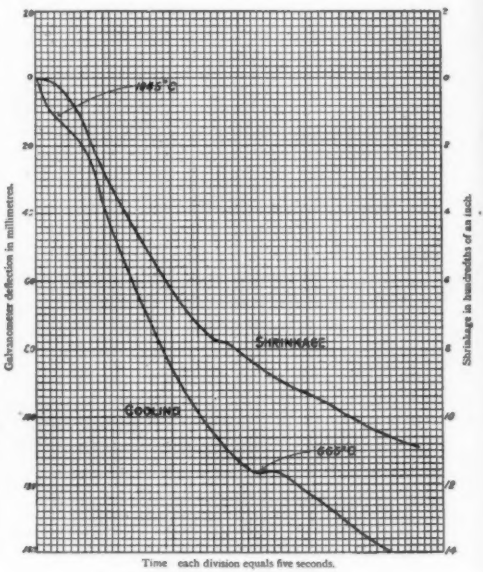

FIG. 6.—PURE WHITE IRON.

iron, such as is used for the production of very grey or fluid castings.

4. *Close-Grained Good Foundry Iron.*—This metal was from a broken-up casting; it was soft and grey, and would give good results for general purposes, so long as the cooling were not too slow.

The composition of these materials was as follows:—

—	White iron.	Gray hematite.	Northampton.	Cast iron.
Carbon, combined	2.73	0.86	0.15	0.79
,, graphitic	—	2.53	2.60	2.73
Silicon	0.01	3.47	3.98	1.41
Sulphur	trace	0.03	0.03	0.07
Phosphorus ...	0.01	0.04	1.25	0.95
Manganese ...	trace	0.55	0.50	0.43

In each case melting was carefully performed in a covered Stourbridge fireclay crucible, some charcoal being placed in the crucible with the charge to prevent loss by oxidation. The large number of separate test-bars were not afterwards separately analysed, as considerable experience with this class of test has shown that the changes which take place in such material under these circumstances are practically negligible. The ready assistance and skill of Mr. J. Ward, the university steel-melter, who had charge of this part of the work, should be here acknowledged. The range of temperature covering the melting-points of the metals and alloys examined in the progress of this research was upwards of 1,000 degrees C., so that no uniformity of pouring temperature was possible. In each case the object was to pour the metal at a heat which would ensure the mould being completely filled and allow solidification to begin within a few seconds after pouring. The head of metal was about 2 in., but the depth of the depression in the head varied very much, according to the shrinkage of samples.

An examination of the shrinkage and cooling curves for white iron, given in Fig. 6, show only one well-marked retardation in each curve at about two and a half minutes after pouring, the temperature being about 665 degrees C. There is also a lag in both curves during the first twenty seconds; this lag is probably due to the well-known pasty stage through which white iron passes when solidifying. In the case of white iron there is no actual expansion at any temperature during cooling; the rate of contraction is sharp, and the shape of the curve very nearly that of a normal metal such as lead, tin, or copper.

The curves for non-phosphoric grey pig-iron, given in Fig. 7, show, on the other hand, two actual expansions during cooling, and each expansion is accompanied by a distinct rise in temperature. The first of these retardations occurs about fifteen seconds after solidification has commenced, and with a temperature of about 1,135 degrees C. (the readings taken varying from 1,120 degrees to 1,150 degrees C.); while the second arrest takes place some two and a half minutes later, and at a temperature of 895 degrees C.

It may be added that the exact tem-

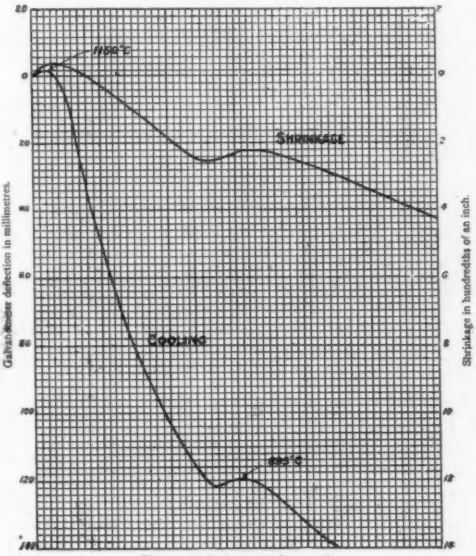

FIG. 7.—GREY HEMATITE IRON.

perature of the first arrest is difficult to observe owing to the rapidity of cooling and the short interval of time over which it extends.

The phosphoric grey pig-iron, of which contraction and cooling curves are given in Fig. 8, has three actual expansions during cooling and three corresponding retardations in the cooling curve, though these do not appear to give actual rises in temperature. The first arrest reaches its maximum after about twenty to thirty seconds, and at a temperature of 1,060 degrees C.; the second occurs after about one and a half minutes, and at a temperature of 900 degrees C.; while the third is very marked and long continued,

beginning about two minutes after solidification and lasting for about 160 seconds, the temperature arrest being at 730 degrees C. The results may be summarised as follows :—

	Iron containing		
	Carbon only.	Carbon and Silicon.	Carbon, Phosphorus, and Silicon.
First arrest ...	Almost absent	At 1,135°	At 1,060°
Second arrest ...	Absent	Absent	At 900°
Third arrest ...	At 665°	At 695°	At 730°

second expansion is faint, and might even be overlooked. Its presence becomes quite evident, however, if a straight-edge be applied to the curve, or if the curve be carefully compared with that given by non-phosphoric iron.

A number of interesting points may be noted in connection with the third expansion in these experiments. In the first place it should be pointed out that the result of Mr. Keep's work is confirmed, while Mr. Osmond's prediction as to the temperature of this arrest is found to be substantially accurate. An intermediate small retardation, previously recorded by Mr. Hudson, with slowly cooling North-

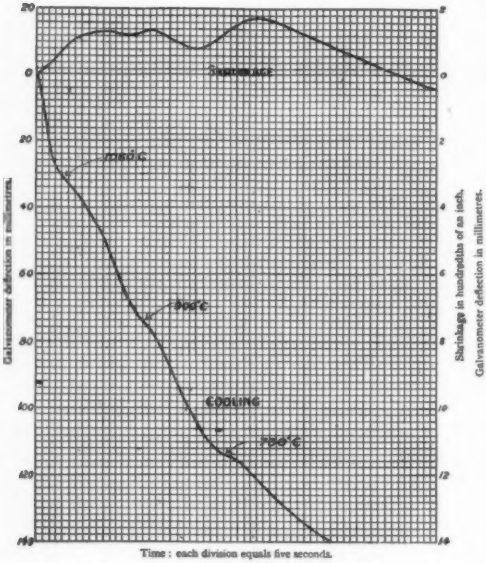

FIG. 8.—GREY NORTHAMPTON IRON.

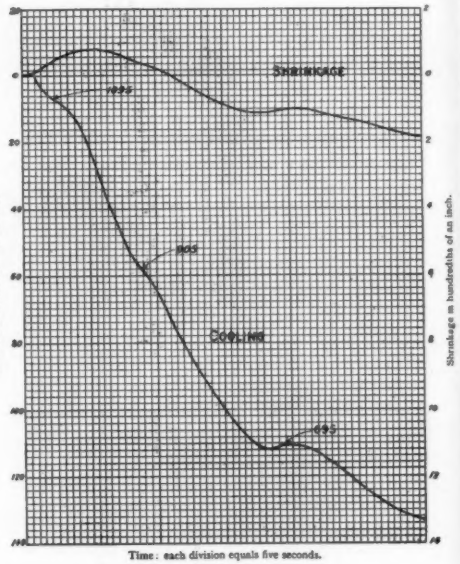

FIG. 9.—FOUNDRY CASTING.

It must not be supposed that only sharp and definite curves of the three types above given are met with when dealing with cast iron in everyday practice. Pig-irons or foundry mixtures differ widely in composition, and in consequence all kinds of curves are obtained, from Fig. 6 on the one hand to Fig. 8 on the other. The cooling and contraction curves of a soft close-grained iron, of which the composition has already been given, will be found on Fig. 9. In this it will be noted that the three retardations in the cooling curve are distinctly indicated, while in the contraction curve the first and third expansions are plainly seen; but the ampton iron at about 850 degrees, is not observed in these experiments, probably owing to the more rapid rate of cooling. As the records were not taken below about 750 degrees in the previous experiments, the third retardation was not reached. The remarkable point about this third expansion is the low temperature at which it takes place, when its volume and duration are considered.

In the absence of silicon the change of volume is very small and the temperature 665 degrees C.; with intermediate silicon the expansion becomes marked, and occurs at about 695 degrees C.; with about 4 per cent. of silicon the expansion

becomes very large indeed, and takes place at about 730 degrees C. Although this expansion takes place at about the temperature of pearlite formation, it cannot be due to this cause, since white iron contains more pearlite than very grey iron, yet the expansion noted with white iron is relatively quite negligible. The presence of silicon leads to an expansion which takes place at a higher temperature and to a vastly increased amount. If it be assumed that coarse-grained or flaky graphite separates during the first expansion, as there appears every reason to believe, then the question arises whether the third expansion is not due to the separation of temper carbon, from, or instead of, pearlite, under the influence of silicon? Professor Lodin has recalled the fact that Forquignon in 1881 mentioned the segregation of carbon from carburetted iron annealed at relatively low temperatures.* According to Wüst† and Geiger, temper carbon results from the decomposition of carbide, which forms in small quantities on heating white iron even to low temperatures. The main quantity is, however, formed suddenly as soon as a certain temperature is reached; this temperature depends on the quantities of other substances which are present in the iron. The temperature which is usually regarded as best for the production of temper carbon from white iron is about 900 degrees, though Charpy and Grenet have shown that by heating white iron to 700 degrees C. for only a few hours seven-eights of the combined carbon was decomposed.‡ But if, as suggested by Heyn,§ iron carbon alloys above 700 degrees are in a metastable condition, which silicon tends to render more stable, the stable condition being that of ferrite and graphite, then it will be evident that each addition of silicon will cause the separation of graphite (in the form of temper carbon) to take place more readily from a cooling mass of cast iron; or, in other words, at a higher temperature. The analyses given by Mr. Keep (see Fig. 2) are not in accordance with the view here expressed, unless, indeed, it be assumed that in the presence of so much silicon the cooling of the test-bars was not sufficiently rapid to prevent the separation of carbon in the amorphous condition. If temper carbon is not separated at this third retardation or at a temperature of about 700 degrees C., it is difficult to account for the marked expansion which occurs. It may be noted that white iron castings are known to increase distinctly in volume during annealing, due, doubtless, to the separation of temper graphite.

In conclusion, it may be pointed out that the observation of the changes of volume which take place during the solidification and subsequent cooling of cast iron affords the ironfounder a ready means of checking and controlling his foundry mixtures. The apparatus is such as can be made by any intelligent mechanic; the actual observation does not require any special skill, and can be completed in about twenty minutes; while the curves when intelligently interpreted afford information as to the chemical composition, the hardness, and the strength of the metal which is, so far as I am aware, supplied by no other single test. These curves should also settle for ever the old controversy as to which metals, if any, expand during solidification, and why in certain cases a piece of cast iron, or other metal, will float on the surface of a molten bath of the same material.

* "Journal of the Iron and Steel Institute," 1905, No. II. p. 75.

† *Ibid.*, p. 781.

‡ "Bulletin de la Société d' Encouragement," vol. cii. (1902), p. 398.

§ "Journal of the Iron and Steel Institute," 1905, No. II. p. 757.

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Mr. H. Martineau, of Ipswich, has acquired the Cranstone Engineering Works, Hemel Hempstead.

Smith's Dry Dock Company, Limited, North Shields, have completed their purchase of a site at Middlesbrough for a new dry dock and shipbuilding yard.

An outbreak of fire occurred during the month on the premises of Messrs. Wilmott & Cobon, engineers, Rotherhithe Street, London, S.E., doing considerable damage.

Nayler & Company, Limited, engineers, Hereford, have appointed Mr. C. W. Leopard, of 32, Queen Victoria Street, E.C., as their London representative.

J. Hopkinson & Company, Limited, of Huddersfield, have appointed Mr. D. Wells, 10, Rue de la Pépiniere, Brussels, as their sole agent in Belgium and Holland.

The Brown Hoisting Machinery Company has decided to discontinue its London offices, and hereafter transact its foreign business directly from the main office at Cleveland, Ohio, U.S.A.

STANDARD SPECIFICATIONS FOR STEEL CASTINGS.*

Process of Manufacture and Chemical Properties.

1. STEEL for castings may be made by the open-hearth crucible or Bessemer process. Castings to be annealed unless otherwise specified.

2. Ordinary castings, those in which no physical requirements are specified, shall not contain over 0.40 per cent. of carbon, nor over 0.08 per cent. of phosphorus.

3. Castings which are subjected to physical test shall not contain over 0.05 per cent. of phosphorus, nor over 0.05 per cent. of sulphur.

Tensile Tests.

4. Tested castings shall be of three classes: "Hard," "Medium" and "Soft." The minimum physical qualities required in each class shall be as follows:—

	Hard castings.	Medium castings.	Soft castings.
Tensile strength, lbs. per sq. in. ..	85,000	70,000	60,000
Yield point, lbs. per sq. in. ...	38,250	21,500	27,000
Elongation, per cent. in 2 in. .	15	18	22
Contraction of area, per cent. ...	20	25	30

Drop Test.

5. A test to destruction may be substituted for the tensile test, in the case of small or unimportant castings, by selecting three castings from a lot. This test shall show the material to be ductile and free from injurious defects, and suitable for the purposes intended. A lot shall consist of all castings from the same melt or blow, annealed in the same furnace charge.

Percussive and Bending Tests.

6. Large castings are to be suspended and hammered all over. No cracks, flaws, defects, nor weakness shall appear after such treatment.

7. A specimen one inch by one-half inch shall bend cold around a diameter of one inch without fracture on outside of bent portion, through an angle of 120 degrees for "Soft" castings, of 90 degrees for "Medium" castings.

Test Piece for Tensile Test.

8. The standard turned test specimen, one-half inch in diameter and two inch gauged length, shall be used to determine the physical properties specified in paragraph No. 4.

Number and Location of Specimens.

9. The number of standard test specimens shall depend upon the character and importance of the castings. A test piece shall be cut cold from a coupon to be moulded and cast on some portion of one or more castings from each melt or blow or from the sink-heads (in case heads of sufficient size are used). The coupon or sink-head must receive the same treatment as the casting or castings, before the specimen is cut out, and before the coupon or sink-head is removed from the casting.

Test Piece for Bending.

10. One specimen for bending test one inch by one-half inch shall be cut cold from the coupon or sink-head of the casting or castings as specified in paragraph No. 9. The bending test may be made by pressure, or by blows.

Yield Point.

11. The yield point specified in paragraph No. 4 shall be determined by the careful observation of the drop of the beam or halt in the gauge of the testing machine.

Sample for Chemical Analysis.

12. Turnings from the tensile specimen, drillings from the bending specimen, or drillings from the small test ingot, if preferred by the inspector, shall be used to determine whether or not the steel is within the limits in phosphorus and sulphur specified in paragraphs Nos. 2 and 3.

Finish.

13. Castings shall be true to pattern, free from blemishes, flaws or shrinkage cracks. Bearing surfaces shall be solid, and no porosity shall be allowed in positions where the resistance and value of the casting for the purpose intended, will be seriously affected thereby.

Inspection.

14. The inspector representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture, prior to shipment.

* As adopted by the American Society for Testing Materials.

MOULDING A BORING BAR IN LOAM OR DRY LAND.

By R. D. W.

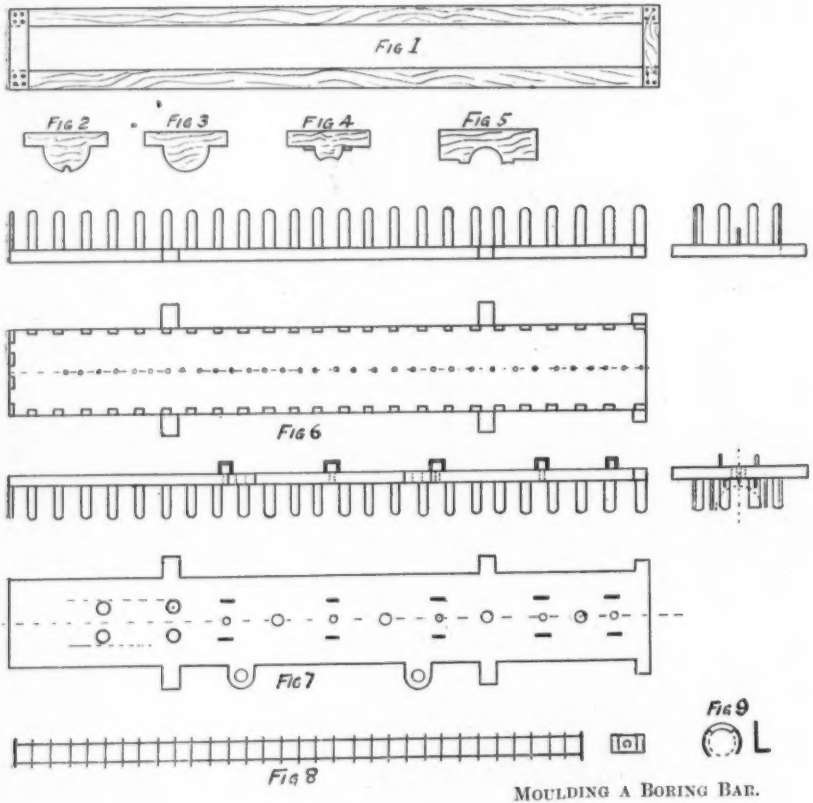
The length of a boring bar often causes such a job to be looked upon as undesirable, even in shops well able to execute such an order, whereas under certain conditions the job should be as easy and as profitable as many which are thought desirable. I will endeavour to describe a method of moulding, economical in production, easy of execution and productive of good results.

The method about to be described is by means of a frame and strickles, with open sand prodded plates instead of box parts.

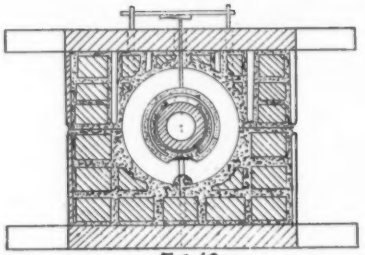
We will suppose such a bar to be 30 ft. long, 15 in. diameter, and of a section as shown in section of complete mould in Fig. 10.

The pattern shop will first be called upon to provide a frame (Fig. 1) of suitable thickness, 17 ft. 6 in. long by 15 in. wide inside, each side to be 6 in. wide, making the usual allowance for contraction. The reason for the extra length above half the total will be seen later on. Two strickles, one for the bottom half (Fig. 2), the other (Fig. 3) for the top half of the mould will be required; also two for the core, one (Fig. 4) to strike the thickness in the bottom half of mould and the other (Fig. 5) to strike the top side of the core, and one similar to Fig. 3 to strike the core prints. Our next requirement is four prodded plates to hold the mould, two of which must be 18 ft. long by 2 ft. 6 in. broad, the other two being 14 ft. long and the same breadth. They must be made strong, —3 in. thick will do—and have suitable provision made for lifting. Fig. 6 gives views of such a plate for the bottom, in which the prods are 1 ft. long; Fig. 7 for the top, in which the prods are 9 in. long, and in which provision is made for fastening the studs which hold the core down as well as for risers, runners, and for turning the plate over. The double row of prods is for the purpose of holding the bricks in position when the plate is turned over. A long and a short plate is required for the top and the same for the bottom. The views shown will, I think, render further explanation unnecessary. Two core barrels will be required, 16 ft. long, fairly strong and rigid; if the shop does not possess two suitable ones, core irons may be made in open sand as in Fig. 8 by means of two long strips and a few cross pieces. Should barrels be available, hangers, as in Fig. 9, can be cast in open sand to hang over them to carry the loam or sand. Having provided the tackle likely to be required, we will now proceed to the actual moulding.

Place the 18 ft. bottom plate on logs or stands to make it a suitable height to work at, build a course of bricks on the bottom, bedding each on a little bricking loam, leaving them rather open; fill in the spaces with clean ashes and continue the bricking at each side and one end up to the top of the prods; the width of the plate allows one brick at each side built flat and one built endwise at the end where the print is, leaving room on the inside for a facing of loam. Lay a straight piece of iron or wood, about $\frac{3}{4}$ in. thick across each end, and take them out of winding, rub and bed loam on and strickle off with a straight edge. You now have a level joint upon which to place the frame (Fig. 1). Fasten this down, and bringing strickle (Fig. 2) into use, build up the inside with pieces of brick, leaving room for a facing of loam; face it up, strickle off and finish with a fine coat, remove the frame and finish the open end by levelling up with loam; make holes down to the plate for the studs to go in. You now have a 17 ft. length of the bottom half of the mould, which can be placed in the stove to dry. Proceed in the same manner with the short length, making it 13 ft. long, and the top halves, spread a little loose hay on the top plates to take the vent away, build runners in and make holes for the risers and studs. The longest bottom piece will have dried in the meantime, and can now be brought out of the stove and placed on logs as before. The frame is again placed on, fastened down, and the thickness made up with sand by means of the strickle (Fig. 4). The barrel, if such is used, is wound with hay or straw rope and given a coating of clay, the hangers, (Fig. 9) placed on, and the barrel laid in what is now a core box, being bedded on loam, packings being inserted to keep it a proper height up. The barrel is now covered with loam, care being taken to rub it thoroughly on the barrel and rope, and the core swept up by means of the strickle (Fig. 5), the frame removed and the whole placed in the stove. Should the core iron be used loose hay ropes will be used to bring the vent to the centre, where a train of ashes must be laid, small lifters being placed in where necessary. In either case, packings must be inserted down to the iron or barrel to correspond with the stud holes in the top half of mould. Next day the core can be lifted



MOULDING A BORING BAR.



out and the other half made in the same way.

The mould, when dry, must be rubbed up, the ends squared and placed together, the short top piece being placed on the long bottom piece and the long top on the short bottom, so that the inside edges join, and guides marked on the outside, so that when finally closed the joints will meet accurately. All parts can now be blackened and returned to the stove.

In closing, bed logs or plates firmly in the floor, level them and place the bottom parts upon them, level and straighten them by means of a chalk line or long straight-edge and cramp together at the joint by means of the lugs shown. Place the cores in upon studs and stud them at the sides to keep them in the centre. Next place the long piece of the top half of the mould upon the short piece of the bottom half, and *vice versa*. Thus the joints are crossed and a firmer and safer job secured. All that remains to be done is to cramp the mould together, fasten the studs down, stop the joints well in, make the runners and risers up and the job is ready to cast. Have some good metal, run a little through the mould, feed well and the casting ought to be perfectly sound. A section of the complete mould is shown in Fig. 10.

While I have described a particular job, the same principle can be applied to other articles either straight or curved, such as pipes, etc., to which those in need of some such method can readily adapt it. The mould described can be made in dry sand by the same method if desired, or if the stoves are too short for the length it can be made in two equal lengths or even in three parts, the frame being made to suit the length chosen.

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THE MUMFORD MOULDING MACHINE.

The Mumford moulding machines, which are being introduced into this country by Messrs. J. W. Jackman & Company, Limited, Caxton House, Westminster, are the design of Mr. E. H. Mumford, who was for some years at the head of the Tabor Manufacturing Company, and was responsible for the development of that machine from its crude beginning until it became a commercial success. The Mumford machine embodies the points of the Tabor machine, with several improve-

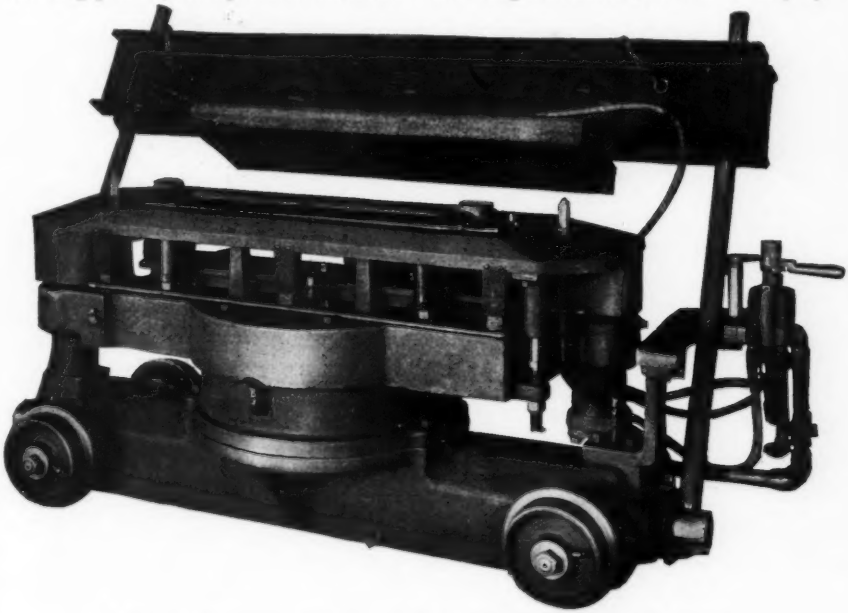

Fig. 1.—Mumford 10½ in. by 40 in. Bottom Ramming Machine Specially Adapted for Radiator Work.

ments. For instance, in the Mumford machine there is no lateral or horizontal vibrator frame, which, in practice, has been often found to move during ramming, thus causing a mis-match of the two halves of the pattern. Attempts have been made to obviate this by a locking bolt, introduced for the purpose of holding the flask frame and vibrator in rigid bond during ramming, but it has been found that this lock is not perfect, and movement can still occur after ramming as the locking mechanism releases. Besides, locking the vibrator to the flask support in this way vitiates the vibrator action and shakes the flask, which it is most important should not be shaken, but should be held absolutely rigid. The Mumford machine vibrator acts vertically only. The flask pins are in the frame, so that there can be no mis-match of the

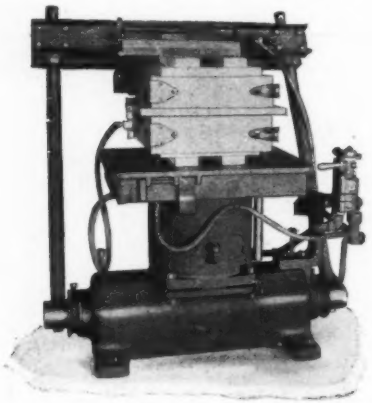

FIG. 2.—MUMFORD PLAIN POWER RAMMING MOULDING MACHINE, SHOWING VIBRATOR ATTACHED TO FRAME AND SNAP FLASKS AND WOODEN MATCH PLATE.

moulds from any cause. These machines, which are shown in Figs. 1, 2 and 3, have had a wonderful reception in the United States. The E. H. Mumford Company was established on April 1, 1905, at which date not even a drawing had been prepared, but so much energy has been displayed in establishing the business, that in the short period of one year which has elapsed since its foundation, over 185 Mumford moulding machines have been made and sold. One concern, the United Shoe Machinery Company, Beverley, Mass., have installed as many as twenty machines.

The radiator machine illustrated herein is the first machine of this type which has been constructed. This machine rams from the bottom against the flask bars, and sets the chaplets from the pattern. One of these machines turns out 15 moulds per hour, operated by two men

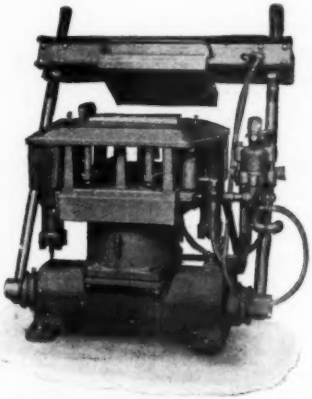

FIG. 3.—MUMFORD POWER RAMMING SPLIT PATTERN VIBRATOR MOULDING MACHINE, WITH POWER PATTERN DRAFT FOR FLASKS, 14 IN. BY 16 IN.

who deliver the moulds on the floor, and another man who sets the cores and closes. The machine travels 90 ft. down the shop during its work.

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MESSRS. G. W. GREEN and R. POOLE, mechanical and consulting engineers, Lambeth, London, S.E., have dissolved partnership.

A DISSOLUTION of partnership is notified in connection with the affairs of Messrs. J. Yetton and H. M. Gibb, engineers, etc., Limehouse, London, E., who traded under the style of J. Yetton & Company.

HENRY WHITE & COMPANY, LIMITED, Pontymister Foundry, Risca, have lately been engaged in making castings for three warships, building at Chatham, Devonport, and Pembroke Docks. This firm has recently delivered a large steel tooth wheel made for a local rolling mill. The wheel measured 15 ft. 6 in. in diameter.

R. H. LONGBOTHAM & COMPANY, LIMITED, Ings Foundry, Wakefield, have taken out a provisional patent for an improved friction clutch. This clutch is of the internal friction expanding type, and can be fitted to almost any drum-side, as it gradually takes up the load and releases same without shock when running at any speed up to 1,000 r.p.m.

TRADE TALK.

MESSRS. GILLIES & HORNIDGE recently established a branch at 6, Holborn Viaduct, London, E.C.

MESSRS. DAWSON & DOWNIE, engineers, of Glasgow, have purchased a site at Clydebank for new works.

THE BRANDON BRIDGE COMPANY, LIMITED, of Motherwell, contemplate the erection of a new foundry.

MESSRS. DOBSON & BARLOW, engineers, of Bolton, are looking out for a site near Atherton on which to erect works.

THE Glasgow establishment of Babcock & Wilcox, Limited, has been removed to 29, St. Vincent Place, Glasgow.

MESSRS. COOKE & KNAPMAN (J. Cooke and J. Knapman), engineers, etc., of Burnley, have dissolved partnership.

S. A. DANIELL, LIMITED, of the Lion Works, Birmingham, have removed their Glasgow establishment to 34, Robertson Street.

MESSRS. STEVENSON & M'GUFFIE, consulting engineers, have removed to Caledonian Chambers, 87, Union Street, Glasgow.

MR. GILBERT LITTLE, of Gilbert Little & Company, Smethwick, has purchased new engineering works at Great Horton, Bradford.

J. CLAYTON & SONS, Chesterfield, have appointed J. Holmes, Limited, of 46, Grange Walk, Bermondsey, S.E., as their London agents.

A. F. CRAIG & COMPANY, LIMITED, Caledonian Engine Works, Paisley, have removed their London office to 30, Great St. Helen's, E.C.

AT Messrs. J. & R. Ritchie's Acklam Foundry, Middlesbrough, an outbreak of fire occurred recently, but very little damage was done.

THE public examination of Messrs. Gilbert Taylor & Company, ironfounders, Blantyre, has taken place during the month at Glasgow.

THE discharge from bankruptcy of Mr. B. Elton, managing director of the Park Lane Foundry, Limited, Tipton, has been suspended for two years.

MESSRS. UTTLEY BROTHERS, Bank View Works, Manchester, have appointed Mr. A. Dick, of 93, Hope Street, Glasgow, to be their sole Scottish representative.

A RECEIVER and manager has been appointed in connection with the affairs of Schiele Union Engineering Company, Limited, of Pollard Street, Manchester.

MESSRS. J. G. STATTER, G. V. FOWLER, C. J SIMEON, and E. A. M. BINDLOSS, engineers, Birmingham, have dissolved partnership so far as regards Mr. G. V. Fowler.

THE gas and oil-engine patterns, etc., of the Commercial Engineering Company, Blackburn, have been purchased by Oldham & Sons, Limited, engineers, of Dukinfield.

MESSRS. W. H. MARLAND and T. HARRISON, brass and iron founders, Hyde, trading under the style of W. H. Marland & Company, notify a dissolution of partnership.

BENNETTS' IRONFOUNDRY COMPANY, LIMITED, of Ardwick, Manchester, have started manufacturing the patent boiler or furnace door and frame invented by Messrs. J. Thomas & Son.

J. BUCKTON & COMPANY, LIMITED, Leeds, have supplied to the Cardiff Railway Company one of the largest chain testing machines in the country, having a testing capacity of 350 tons.

A LARGE engineering firm have definitely announced their intention of removing their works to Peterborough, and negotiations for the purchase of the necessary land are proceeding.

MESSRS. WILLIAM WILSON & COMPANY have removed from their old premises, the Lilybank Boiler Works, Eglinton Street, Glasgow, to the new works in London Road, in the same town.

MESSRS. F. BRADSHAW and R. BRADSHAW, carrying on business as F. & R. Bradshaw, Accrington, Lancashire, engineers, brass founders, and machinery agents, have been adjudged bankrupt.

MR. LLOYD-GEORGE recently introduced a Bill in the House of Commons to provide for taking a census of production in the year 1908. The question as to whether the census is to be biennial or quinquennial is to be left to the option of the House.

MESSRS. NASMYTH, WILSON & COMPANY, Bridgewater Foundry, Patricroft, near Manchester, have had a large order in hand for locomotives for the Indian State Railways. The firm are now building boiler-erecting shops adjoining the Bridgewater Foundry.

MR. J. A. MUIRHEAD, lately connected with Edwin Danks & Company, Limited, boilermakers, Oldbury, has entered into partnership with Mr. J. E. Lawler, 39, Lime Street, London, E.C., and will trade under the style of Lawler & Muirhead.

W. & T. Avery, Limited, Soho Foundry, Birmingham, are supplying the North-Western Railway of India with one of their locomotive testers, with twelve tables, having a capacity of 10 tons. The firm have also supplied 54 of their portable testers to the East Indian Railway Company, the Southern Mahratta Railway Company, and the Eastern Bengal Railway Company.

The Malleable Steel Castings Company, Limited, of Pendleton, Manchester, have opened an office at Queen Anne's Chambers, London, S.W., under the charge of Mr. E. Peckham, chairman of the company. In addition to the business previously done by the company, special attention will now be paid to the manufacture of supply parts for Peckham, Brill, and Brush trucks.

Mr. Robert Buchanan (President of the British Foundrymen's Association), delivered a lecture at Cardiff College recently, on "The Mixing, Melting, and Cooling of Cast Iron." The meeting was organised by Mr. Charles Jones (Ninian Foundry, East Moors), and it is stated that the success of the meeting will probably lead to the formation of a branch of the British Foundrymen's Association at Cardiff.

The engineering industry will shortly be established at Alloa, in Scotland, Messrs. Shearer & Young, engineers and shipbuilders, Glasgow, having decided on the erection of works, drawing and general offices, machine and blacksmiths' shops, etc., in the town. The new works will cover meantime an acre of ground, but it is understood a considerable stretch of ground has been reserved by the firm for future extensions.

It has become increasingly apparent during the recent boom in the cotton industry, that engineering firms who are invited to quote for the necessary plant and machinery for new mills, are given plain hints that the placing of contracts will be dependent upon the number of shares taken up by the contractors in the new company. This has developed to such an extent during the last few months that the leading engineering firms in Lancashire and Yorkshire have at last combined to protect themselves against this very questionable practice, the companies included being:—Messrs. D. Adamson & Company, Dukinfield, near Manchester; Ashton, Frost & Company, Limited, Bank Top Foundry, Blackburn; Browett, Lindley & Company, Limited, Sandon Engine Works, Patricroft, near Manchester; David Bridge & Company, Castleton Iron Works, Castleton, near Manchester; Buckley & Taylor, Limited, Castle Iron Works, Oldham; Clayton, Goodfellow & Company, Limited, Atlas Iron Works, Blackburn; Cole, Marchant & Morley, Limited, Prospect Foundry, Bradford; Joseph Foster & Sons, Soho Foundry, Preston; Gimsons, Limited, Stayley Iron Works, Stalybridge; John Heald, Limited, Phœnix Foundry, Chorley; Hick, Hargreaves & Company, Limited, Soho Iron Works, Bolton; John Musgrave & Sons, Limited, Globe Iron Works, Bolton; John & William McNaught, St. George's Foundry, Crawford Street, Rochdale; Petrie & Company, Limited, Phœnix Foundry, Rochdale; Pollit & Wigzell, Limited, Bank Foundry, Sowerby Bridge; George Saxon, Limited, Openshaw Engineering Works, Manchester; Scott & Hodgson, Limited, Guide Bridge Iron Works, Guide Bridge; C. Whittaker & Company, Limited, Union Foundry, Haslingden; William Whittaker & Sons, Sun Iron Works, Oldham; Woodhouse & Mitchell, Limited, engineers, iron and brass founders, Brighouse; Wood Brothers, Valley Iron Works, Sowerby Bridge; and Yates & Thom, Limited, Canal Engineering Works, Blackburn. At a recent meeting of representatives of these manufacturers it was unanimously resolved "not to take up, or to be interested in the taking up, of any share, the finding of loan money, or otherwise financially assisting the promotion of new cotton mills when such financial assistance is a condition upon which the order is given." It need hardly be stated that these somewhat questionable practices have only been originated by a certain class of company promoter whose financial standing, in many cases, is indifferent.

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PERSONAL.

Sir James Kitson, M.P., has been publicly presented with the freedom of the City of Leeds.

Mr. S. J. Robinson, of William Jessop & Sons, Limited, has visited the United States during the month.

Mr. W. J. Luke has been appointed a local director of John Brown & Company, Limited, Clydebank.

The late Mr. J. Bishop, of Messrs. Preston & Bishop, ironfounders, Birmingham, left estate valued at £15,009.

Mr. W. A. Tritton has been appointed general manager of Wm. Foster & Company, Limited, engineers, of Lincoln.

EVANS'S

CORE VENTS

$\frac{1}{16}$, $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$ & $\frac{1}{2}$ diameter.

AS SUPPLIED TO H.M. GOVERNMENT

AND

ALL THE LEADING FOUNDERS.

JAMES EVANS & CO.,

Britannia Works,

MANCHESTER.

Telegrams { "LADLES, MANCHESTER." / "BLACKINGS, GLASGOW."

Mr. E. P. Lewis has been appointed manager of the South Wales Steel Works, Llanelly, of Richard Thomas & Company, Limited.

The late Sir James Miller, Bart., chairman of the Shotts Iron Company, Limited, left personal estate valued at £437,296.

Mr. J. H. Walters has been appointed manager and representative of the Steam Cylinder Lubricator Company, Limited, of Manchester.

Mr. J. McKechnie, of Vickers, Sons & Maxim, Limited, met with an accident whilst riding on horseback near Ulverston recently.

Mr. J. E. Russell, ironfounder, of Derby, has been appointed a member of a Derby Corporation Committee to supervise contracts.

The late Mr. S. Loveridge, of Messrs. T. & C. Clark & Company, ironfounders, Wolverhampton, left estate valued at £615,892 gross.

Mr. W. Bird, of the Dalmellington Iron Company, Limited, has been elected a director of the Parkgate Iron and Steel Company, Limited.

The estate left by the late Mr. R. Tronbridge, London manager for the Weardale Company, is valued at £5,069 6s. 6d. gross.

Mr. G. Senior, chairman of George Senior & Sons, Limited, Ponds Forge, Sheffield, has now practically recovered from his recent illness.

Mr. James Oakes, of the Alfreton Iron Works, has been appointed one of the representatives of the Derbyshire County Council on the County Councils Association.

Mr. W. M. Richardson, of the Carmuirs Iron Company, Falkirk, is a member of the committee appointed by the Board of Tarde to inquire into the bankruptcy laws.

Mr. Alfred Swingler and Colonel Buchanan, the heads of two Derby firms connected with the iron industry, have been re-elected members of the Committee of the Derbyshire Branch of the National Association for the Employment of Discharged Soldiers.

Mr. J. W. Sowter, manager of the foundry at the Newhall Works, Sheffield, of the Brightside Foundry and Engineering Company, Limited, has been the recipient of a presentation from the officials and staff of the company in celebration of his 40 years' association with the works.

Mr. J. Hardisty has been appointed works manager for John Abbot & Company, Limited, Gateshead-on-Tyne. Mr. Hardisty has latterly occupied the position of general manager of a large engineering works in Birmingham. Mr. H. E. Brice has been appointed manager of the brass yard, etc., at the same establishment.

——o——

OBITUARY.

Mr. Steiner-Sulzer, head of the well-known firm of Messrs. Sulzer Brothers, of Winterthur.

Mr. William Dickinson, eldest son of Mr. John Dickinson, J.P., of Palmer's Hill Engine Works, Sunderland.

Mr. R. Coulson outdoor manager of the firm of Messrs. A. Rodger & Company, shipbuilders, Port Glasgow.

Mr. W. H. Richards, of the Vulcan Casting Foundry, Darlaston Green, at his residence in Walsall, at the age of 49 years.

Mr. D. C. Beadon, manager of Messrs. Hawthorn, Leslie & Company's St. Peter's Works, suddenly, at the age of 48 years.

Mr. A. B. Brown, head of the firm of Brown Brothers & Company, Limited, hydraulic and general engineers, Edinburgh, at 67 years of age.

Mr. C. W. Kayser, chairman and managing director of the firm of Kayser, Ellison & Company, Limited, Carlisle Works, Sheffield, in his 65th year.

Mr. H. Waterston, managing director of the Victoria Iron and Steel Company, Limited, of Coatbridge, and previously secretary to the firm of Thomas Ellis, Limited, of the same town.

Mr. J. E. Mathewson, an esteemed member of the British Foundrymen's Association. The deceased was managing director of Geo. Richards & Company, Limited, Broadheath, near Manchester.

Sir Thomas Richardson, at his residence, Kirklevington, Yarm, at the age of 60 years. In 1868 the deceased gentleman entered the important engine works at Hartlepool, of which his father was the head, and on the latter's death in 1890, became its head, continuing in that position until the amalgamation with Messrs. Furness, Westgarth & Company, Limited, ten years later, under the style of Richardson, Westgarth & Company, Limited. Of this firm Sir Thomas was the chairman, and Mr. J. M. Richardson the active manager.

Ganister, Cupola Blocks, Fire Bricks,

Fire Clay.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

Steel Moulders' Composition, Silica Cement

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

"GLYCO" METAL COMPANY, LTD.,

MANCHESTER.

REGISTERED TRADE MARK — GLYCO GLYCO GLYCO GLYCO

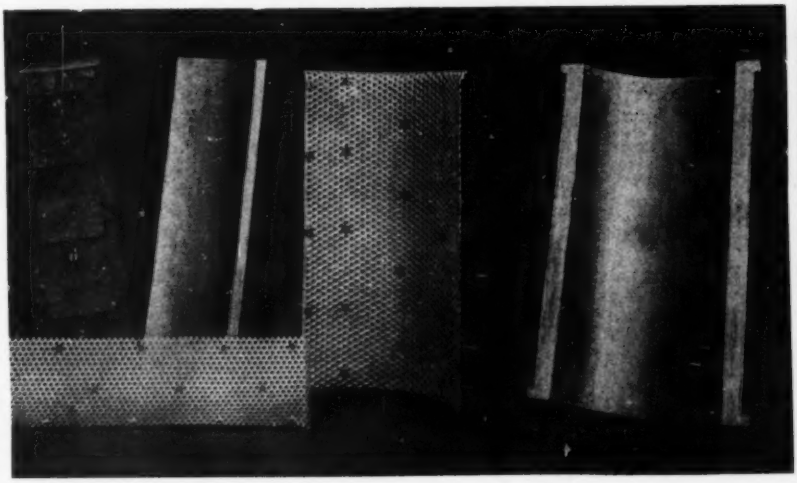
WE GUARANTEE "GLYCO" AS A BEARING LINER

EQUAL IN EFFICIENCY

TO THE HIGHEST PRICED TIN ALLOYS AT LESS THAN HALF THEIR COST.

PATENT GLYCO-EMBEDDED SKELETON BEARINGS.

The Illustration shows a Crank-Shaft Bearing, consisting of Steel Shell with Bronze Skeleton embedded in "Glyco."



Strength, Efficiency, Low First Cost, and 50 per cent. Saving in Lubrication.

NEW COMPANIES.

STOCKTON STEEL FOUNDRY COMPANY, LIMITED.—Capital, £20,000, in £1 shares.

WEDDELL & COMPANY, LIMITED.—Capital, £1,000, in £1 shares, to carry on the business of engineers, etc.

SPHINX ENGINE COMPANY, LIMITED.—Capital, £1,400 in £1 shares. Registered office: 6B, Virginia Street, Southport.

HOLEHOUSE, BLAKE & COMPANY, LIMITED.—Capital, £2,000, in £1 shares, to carry on the business of engineers, ironfounders, etc.

WEBSTER & BENNETT, LIMITED.—Capital, £30,000, in £1 shares, to acquire the ironfounding business carried on at Coventry as Webster & Bennett.

JAMES GUTHRIE & COMPANY, LIMITED.—Capital, £1,000, to acquire the business of James Guthrie & Company, mechanical engineers, founders, etc., Liverpool.

WILLIAM DIXON, LIMITED.—Capital, £1,000,000, in £10 shares, to acquire the business of William Dixon, Limited. Registered office: 1, Dixon Street, Glasgow.

JOHN WEBB & COMPANY, LIMITED.—Capital, £25,000, in £1 shares, to acquire the business of John Webb & Company, brass and ironfounders, etc., Hockley, Birmingham.

HUBERT MAY & COMPANY, LIMITED.—Capital, £2,000, in £1 shares, to carry on the business of engineers, etc. Registered office: 16, Hazleville Road, Hornsey Rise, N.

SALMON, WHITFIELD & COLLET, LIMITED.—Capital, £10,000, in £1 shares, to acquire the business of Salmon, Whitfield & Company, and to carry on the business of ironfounders, etc.

W. A. STEVENS, LIMITED.—Capital, £10,000, in £1 shares, to acquire the business of Stevens & Barker, Victoria Works, Maidstone, and to carry on the business of ironfounders, etc.

UNIVERSAL ENGINEERING COMPANY, LIMITED.—Capital, £3,000, in £1 shares, to take over the business of the Universal Engineering Company. Registered office: 4, Chesterfield Street, Nottingham.

TAYLOR & SPINK, LIMITED.—Capital, £1,000, in £1 shares, to carry on the business of engineers, metal founders, etc. Registered office: Church Street Iron Works, Lytham Street, Newton Heath, Manchester.

ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

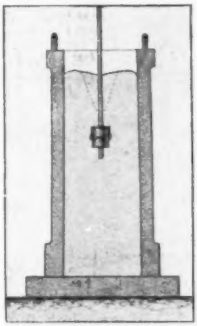
Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

Reducing Piping in Steel Ingots.

STEEL BLOCK SHOWING PIPING.



TIN OF "ANTI-PIPING" COMPOUND IN POSITION.

APPEARANCE OF BLOCK AFTER TREATMENT.

For Particulars apply to

THERMIT LTD.,

27, Martin's Lane, Cannon Street,

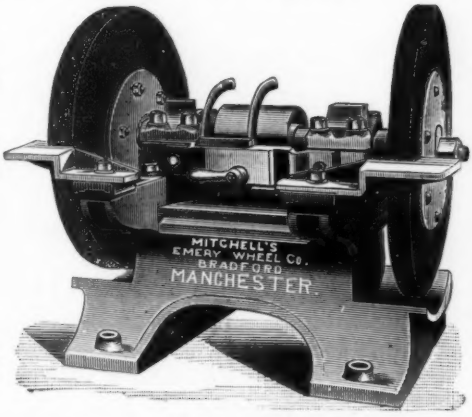
LONDON, E.C.

Telephone: 3749 Central.
Telegrams: "Fulmen, London."

MACHINES For all Purposes. **WHEELS.**

Complete with Emery or Corundum Wheels from **£2** upwards.

Special Machines Designed.



Emery or Corundum from 1 in. x $\frac{1}{8}$ in. to 50 in. x 12 in.

Enquiries solicited.

MITCHELL'S EMERY WHEEL Co.,

Mill Street, Bradford, MANCHESTER.

Also at LONDON, GLASGOW, and BELFAST. LISTS FREE.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	1905-6.	1904-5.
Iron—Scotch pig warrant ... ton	56/-*	—
—Middlesbro' warrants ... ... ton	49/6½	45/8½
—W.C. M/nos Bessemer ... ... ton	67/6	57/6
—Stock, Scotch, Mar. 31 ...tons	12,380	18,000
Copper—Chili bars, GMB ... ... ton	£85 17/6	£65 3/9
—Stock, Europe & afloat... ... tons	9,583	17,227
Tin—English ingots ton	£186 0/0	£138 0/0
—Straits ... ton	£185 10/0	£136 7/6
—Stock, Ldn. Hlnd and aflt ... tons	11,959	14,207
Lead—English pig ton	£17 1/3	£13 2/6
Spelter—Ord. Silesian ... ... ton	£27 12/6	£23 15/-
Quicksilver-(75lb.) bottle	£7 5/0	£7 7/6
Antimony—Regulus ... ... ton	£120 0/0	£37 0/0

*Settlement price, sellers, cash.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 12 6	to	7 2 6
Pipes, 1½ to 2½ in.	5 0 0	to	5 2 6
,, 3 to 4 in....	4 12 6	to	4 15 0
,, 5 to 8 in.	4 10 0	to	4 12 6
,, 10 to 16 in....	4 10 0	to	4 12 6
,, 18 to 24 in....	4 10 0	to	4 12 6
Chairs	3 15 0	to	3 17 6
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: —Heavy wrought (mixed), £2 13s. 6d.; light wrought, £1 6s.; heavy cast, £2 6s.; all per ton f.o.b., London. Copper (clean), £78; brass (clean), £53 10s.; lead (usual draft), £15 5s.; tea lead, £13 5s.; zinc, £22 5s.; all per ton delivered merchants yard.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

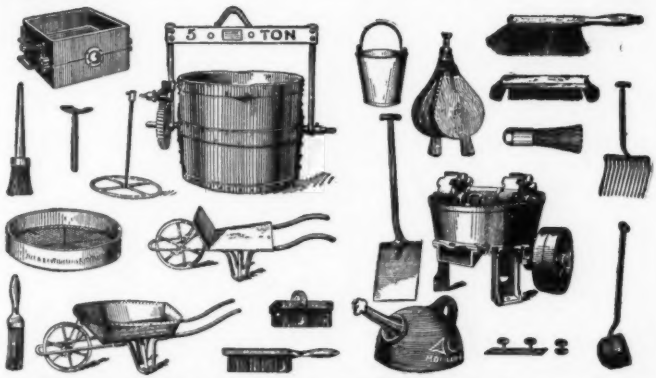
Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE, Near Sheffield.

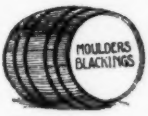
Manufacturers of all

FOUNDRY EQUIPMENTS,

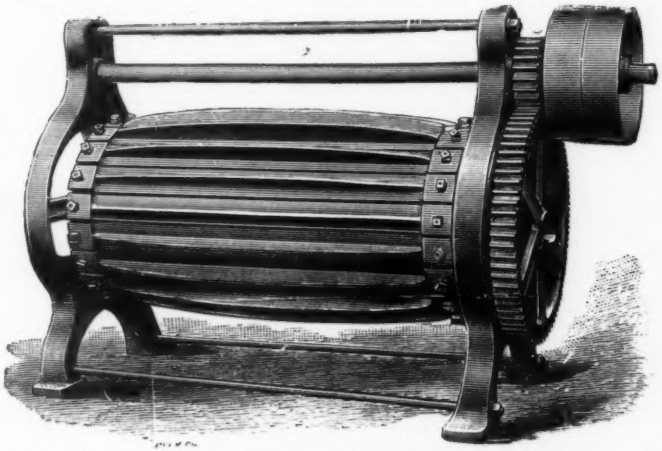
Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.



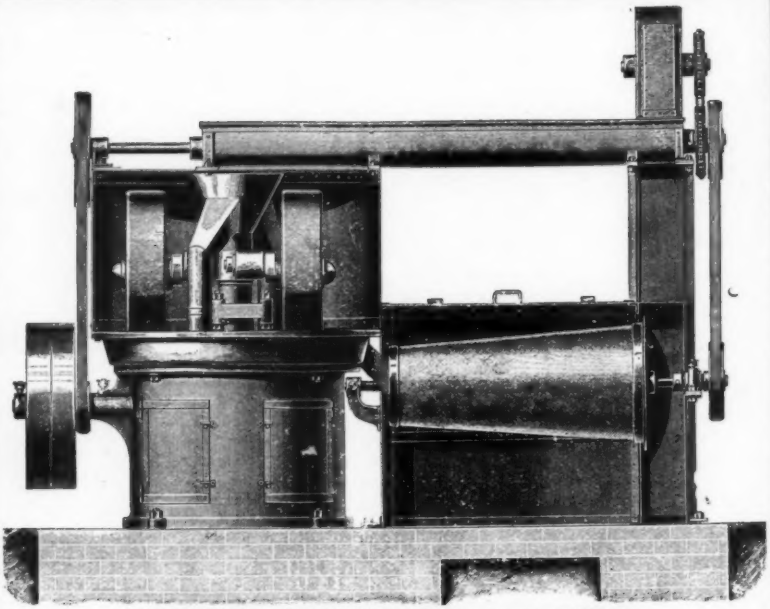
IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

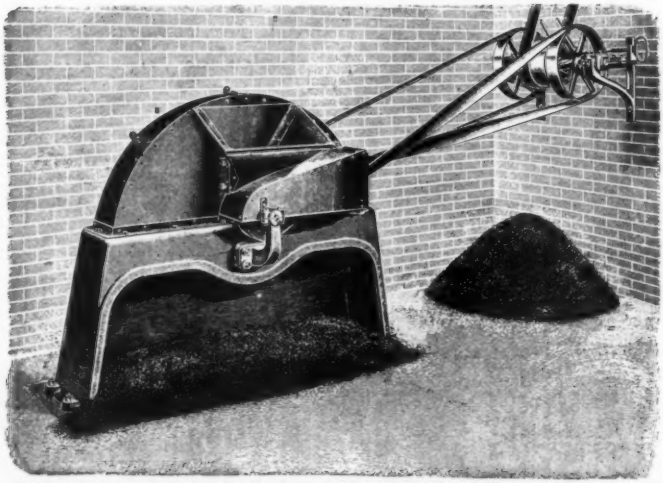
"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

"Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."



COMBINED GRINDING MILL and SIFTER.

CAPACITY 15 CWTS. PER HOUR.



PATENT HORIZONTAL SAND MIXER, Pattern "Sb."

FITTED WITH BALL BEARINGS. CAPACITY 4 TONS PER HOUR.

CHARCOAL BLACKING. COAL DUST. PLUMBAGO.

THE LONDON EMERY WORKS CO., Dept. C., PARK, TOTTENHAM, LONDON, N.

SITUATIONS VACANT AND WANTED.

WANTED immediately for Works in London, a Foreman for Iron Foundry; must be a strict disciplinarian and thoroughly experienced in all branches of Foundry work of an Engineering works.—Apply by letter, stating previous experience and salary required, to Box 559, Offices of THE FOUNDRY TRADES JOURNAL, 165, Strand, London, W.C.

FOR SALE AND WANTED.

FOR SALE, "Root's" Patent Foundry Blowers, &c.

No. 2 size by	"Thwaites"	8 in. outlet	£22.
No. 1 ,,	"Allday's"	7 in. ,,	£20
No. 1A ,,	,,	6 in. ,,	£20.
No. 3 ,,	"Wilkinson"	6 in. ,,	£17.

Two 7 ft. by 4 ft. Vertical Boilers, as new, each... ... ... £34.

For full details address J. LIGHT, Wolverhampton.

CRUCIBLE STEEL CASTINGS for Collieries, Works, and Engineers, from customers' patterns; machined if desired.—P. T. WOODRUFF AND CO., Machen, Newport, Mon.

EVERY IRONFOUNDRY should use Hall's Improved Centrifugal Sand Grinder and Mixer, which utilise the waste sand from the Foundry, and makes it in the best possible condition for Moulding High Class Castings. Capacity 4 tons per hour. Price and Particulars, apply to J. S. HALL & CO., LTD., Midland Ironworks, Newark on-Trent.

FOUNDRY EQUIPMENT.

PATENT CORE MAKING MACHINES

No linseed oil or flour required.

NEW PORTABLE MOULD DRIERS

Moulds dried on the spot in an hour to one hour and a half.

J. W. & C. J. **PHILLIPS,**

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STIGNIC PAINT.

NEWEST AND BEST WASH FOR STEEL FOUNDERS.

PLASTIC CUPOLA GANISTER.

FINEST MATERIAL FOR LINING CUPOLAS AND FURNACES AND SETTING FIRE-CLAY BRICKS.

SPECIAL **STEEL MOULDERS' COMPO.**

STEPHENS & CO., Kidwelly.

MOULDING SAND

FOR

ALL METALS.

The noted Birmingham quality is sent all the World over.

For Prices—

J. WILLIAMS,

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Also Manufacturer of Fine Grade Coal Dust and Foundry Blackings.

COLD BLAST PIG-IRON.

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JAMES DOUGALL & SONS, LTD.,

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Foundry Specialists.

GANISTER, FIREBRICKS,

GANISTER BRICKS, FIRECLAY,

Of the Highest Qualities.

If you are troubled with Defective Fire-Resisting Materials write for Prices.

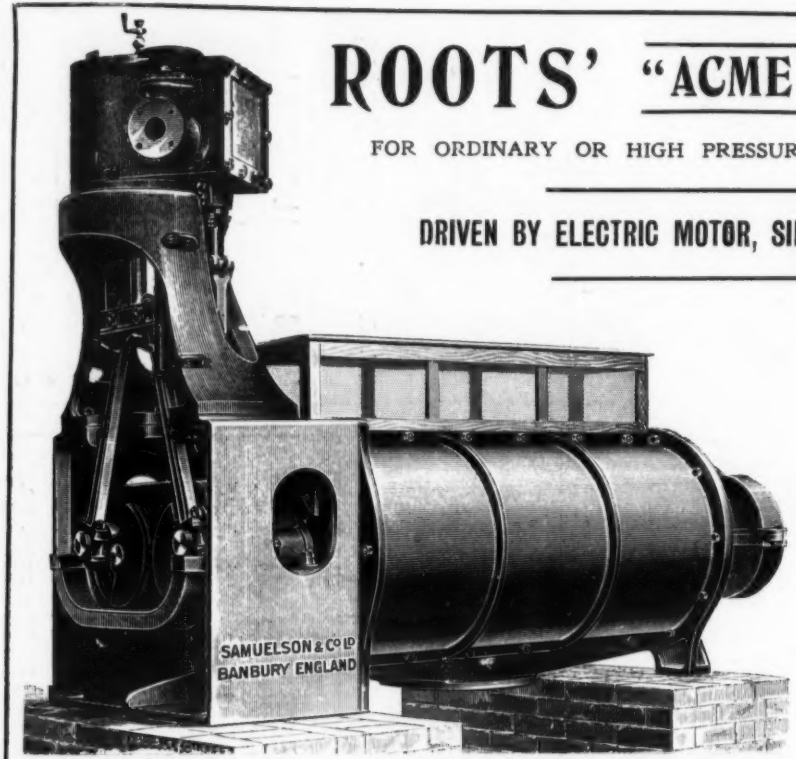
SHIPPING PORTS:

Glasgow, Bo'ness, Grangemouth and Leith.

ROOTS' "ACME" BLOWERS

FOR ORDINARY OR HIGH PRESSURES UP TO 10 LBS. PER SQ. IN.

DRIVEN BY ELECTRIC MOTOR, SIMPLE OR COMPOUND ENGINE.



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For Economical Repetition Work.

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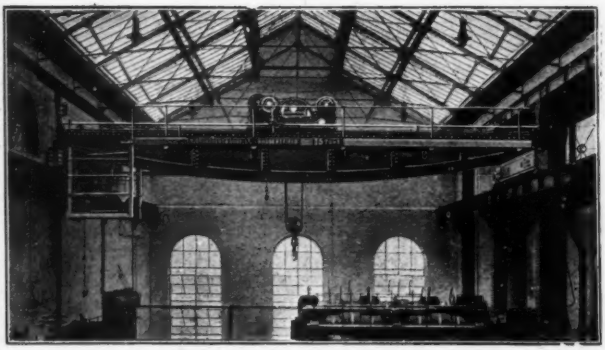

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THOMAS BROADBENT & SONS, Ltd.,
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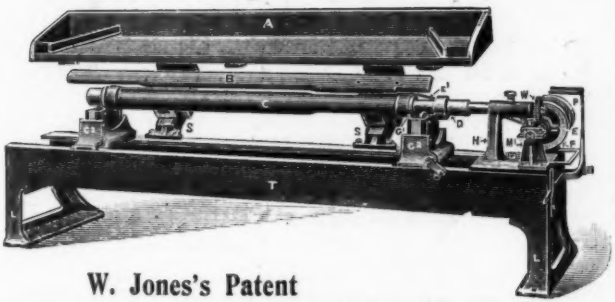
For
Pipe Cores,
18 ft. long and
2 in. to 20 in.
diameter.



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JONES & ATTWOOD,
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The "LEEDS" Dead Length Core Machine.

This machine is made in three sizes with capacities up to 8½ inches, and special arrangements for larger sizes. It is of British manufacture.

Some of our other specialities are Cupolas, Ladles, Mixers, Core Machines (two types), Moulding Machines (Pneumatic, Turnover and Hand-press), Pneumatic Chippers, Pneumatic Rammers, Pneumatic Riddles (three types), Bar Testing Machine, Tumbling Barrel, Overhead Trolley Track, Foundry Sundries.

HORACE P. MARSHALL & CO.,

LEEDS.

£100

WILL BUY

A COMPLETE

COMPRESSED AIR

INSTALLATION,

INCLUDING

"Boreas" Air Compressor, Receiver, Chipping Hammers, Hoists, Sand Blast Apparatus or other Appliances.

ALL OF THE BEST KIND.

Every works should possess one, as it will pay for itself in a very short time.

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SWIFT METALLIC STOPPING

THE NEW FOUNDRY CEMENT.

IT is used for filling up blow holes and sand holes in Cast Iron or Steel Castings.
IT is supplied in powder form and mixed for use with a little water to a stiff paste.
IT dries on a casting in 1 hour, and can be filed up bright in from 6 to 12 hours.
IT is specially useful to all Engineers, Machinists, Foundrymen, &c.
IT is of British Manufacture.

A Small Sample sent Post Free on receipt of your address, or a trial 1 lb. Tin Post Free on receipt of P.O. or Stamps for 1s. 6d.

THE SILENT MACHINE AND ENGINEERING CO., ALBION WORKS, SHEFFIELD.

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THOMAS WILKINSON & CO., LTD.,

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Manufacturers and Exporters of

Iron Moulders' Blackings,

Coal Dust, and other Foundry Requisites.

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PHOSPHOR BRONZE CO., LTD.,

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Cog Wheel Brand
Phosphor Bronze Alloys.
Phosphor Tin (5%).
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BLACK DELPH FIREBRICKS

For High Temperatures.

Also Special Grades for
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BRASS FURNACES.

CRUCIBLE CLAYS.

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38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application t
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW.
36"
32½"

Can also be made in Aluminium.

NEW MOULDING MACHINE.

PICKLES' PATENT.

ASK FOR LIST AND FULL PARTICULARS.

COMPLETE FOUNDRY EQUIPMENT.

JAMES EVANS & CO.,

Britannia Works, MANCHESTER.

TELEGRAMS: "LADLES, MANCHESTER." "BLACKINGS, GLASGOW." TELEPHONE: 2297, MANCHESTER. 3185, BRIDGETON, GLASGOW.